Science Committee Report

Dr. Bradley M. Peterson
Chair, Science Committee

Science Committee Members

Brad Peterson, Chair, The Ohio State University
Carle Pieters, Vice Chair, Brown University

Janet Luhmann, UC Berkeley, Chair of Planetary Science Subcte
Steve Running, University of Montana, Chair of Earth Science Subcte
Scott Gaudi, The Ohio State University, Chair of Astrophysics Subcte
Jill Dahlburg, Naval Research Laboratory, Chair of Heliophysics Subcte (NEW)
Robert Lindberg, University of Virginia, Chair of Planetary Protection Subcte

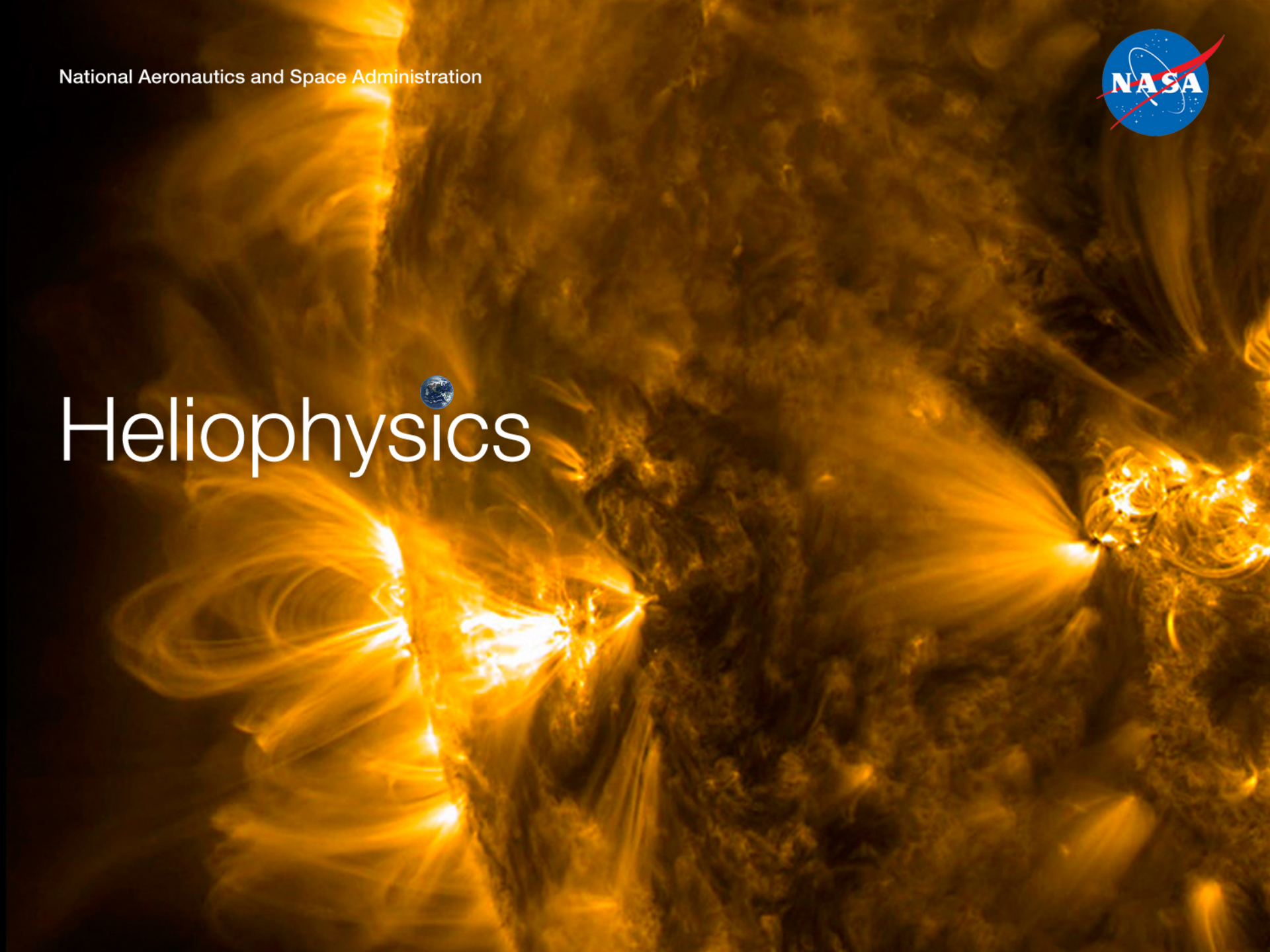
Doug Duncan, University of Colorado
Mark Robinson, Arizona State University
Harlan Spence, University of New Hampshire
James Green, University of Colorado at Boulder
Robert Kirshner, Harvard University
Susan Avery, Woods Hole Oceanographic Institute

David Spergel, Chair of Space Studies Board (*ex officio* member)

Outline

- **Science Results**
- Programmatic Status

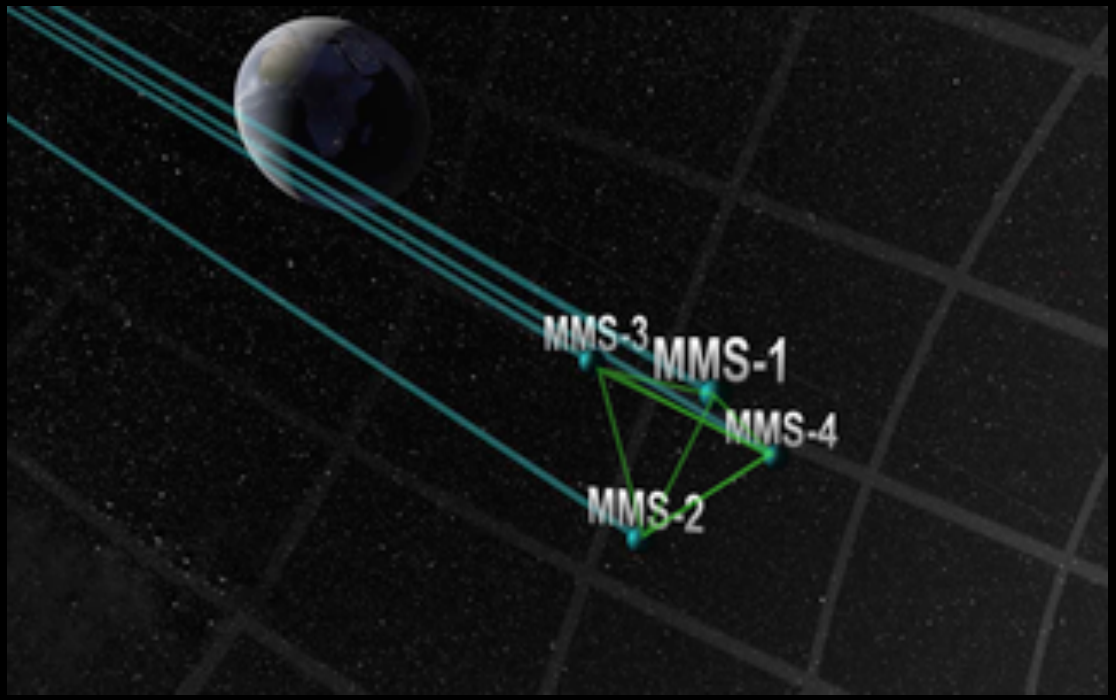
National Aeronautics and Space Administration



Heliophysics

Heliophysics Science Highlights
October 2015

MMS Spacecraft Achieve Tightest Flying Formation Ever!

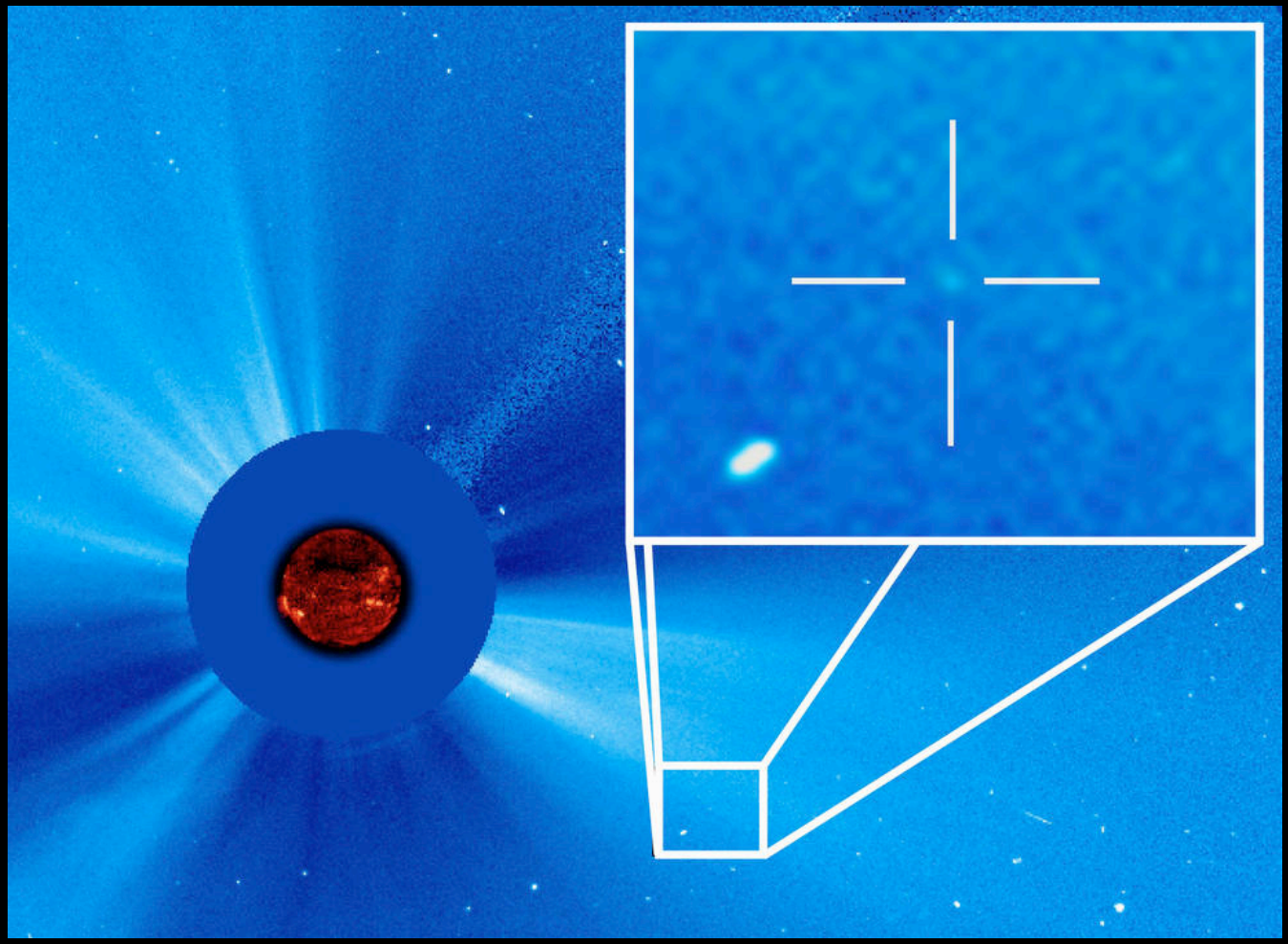


- On Oct. 15, 2015, a NASA mission broke its own record: the four satellites of its Magnetospheric Multiscale (MMS) mission are now flying at their smallest separation, the tightest multi-spacecraft formation ever flown in orbit. The four spacecraft are just six miles apart, flying in what's called a tetrahedral formation, with each spacecraft at the tip of a four-sided pyramid. The close formation is all the more impressive as the spacecraft speed along at up to 15,000 miles per hour and – with their booms extended – each spacecraft covers as much area as a professional baseball stadium.

- When MMS first formed a tetrahedral shape in July 2015, the spacecraft were flying about 100 miles apart. Over the past few months, MMS gradually closed that spacing to just six miles. Another mission, ESA/NASA's Cluster, had times in which two of its four spacecraft were that close, but MMS is the first mission to hold four spacecraft in such close proximity. To achieve this milestone, first the MMS spacecraft dropped down to 40 miles apart, then 15 and finally on Oct. 15 the spacing dropped to its closest point, just a little over six miles apart. After operating over that range, the MMS science team will then decide what spacing was optimal and return to that value.

Heliophysics Science Highlights
September 2015

SOHO Discovers Its 3,000th Comet!

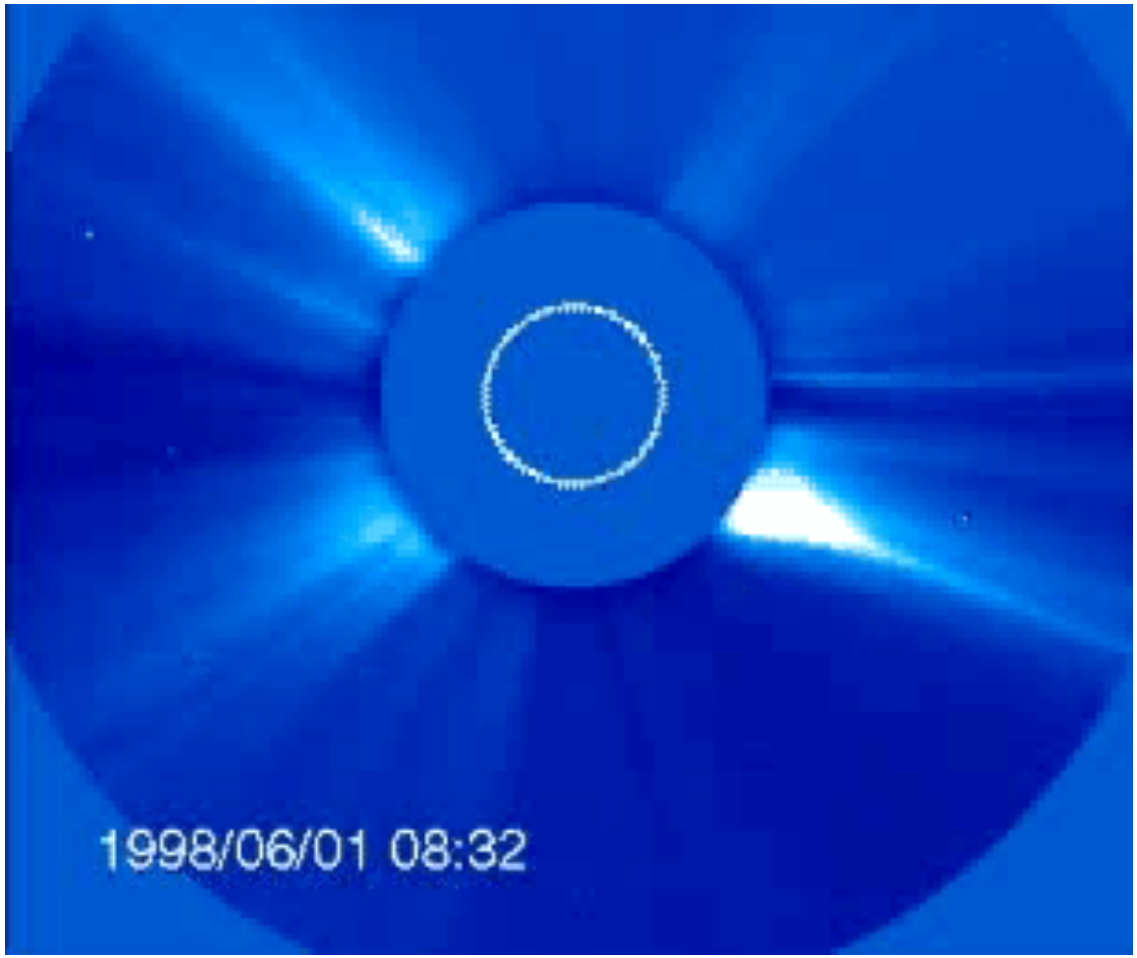


- On Sept. 13, 2015, citizen scientist Worachate Boonplod, of Samut Songkhram, Thailand used data from the Solar and Heliospheric Observatory (SOHO) to discover its 3,000th comet.

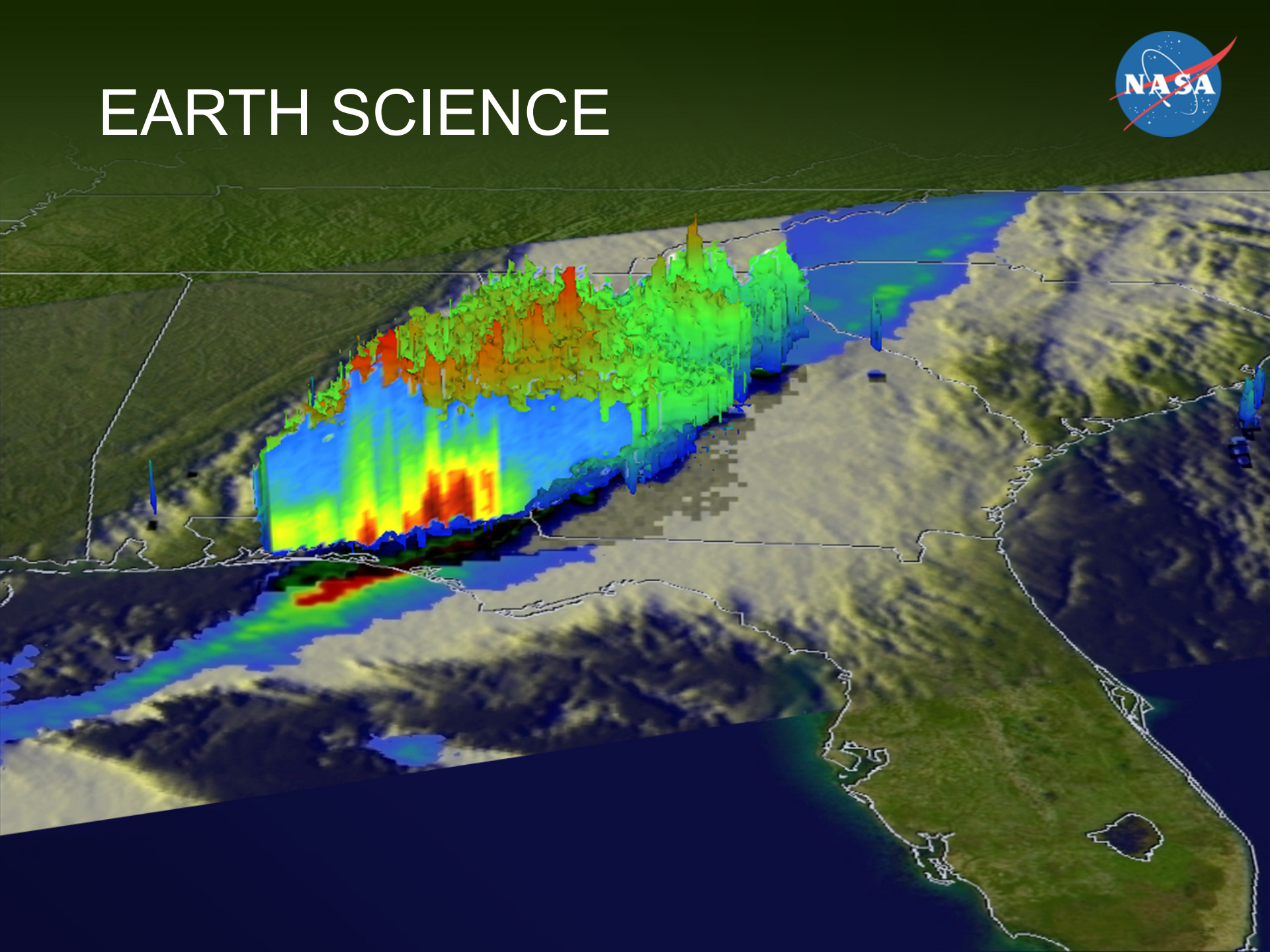
- Prior to the 1995 launch of SOHO, only a dozen or so comets had ever even been discovered from space, while some 900 had been discovered from the ground.

- SOHO's great success as a comet finder is dependent on the people who sift through its data – a task open to the world as the data is publicly available online in near-real time. The result: 95 percent of SOHO comets have been found by these citizen scientists.

SOHO Time Lapse (from 1998)



EARTH SCIENCE

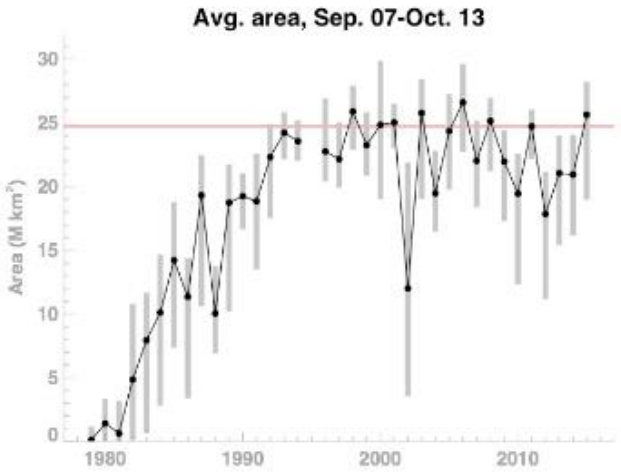


DSCOVR – EPIC (Lunar Transit movie)

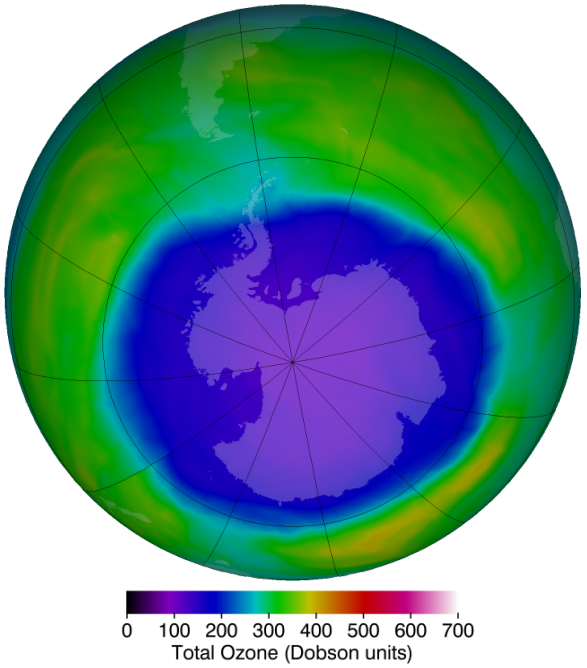
Daily EPIC Imagery: http://epic.gsfc.nasa.gov

2015 Antarctic Ozone Hole

- **On Oct 2, NASA and NOAA scientists indicated that the 2015 Antarctic ozone hole approached its annual maximum. This is the 4th largest ozone hole in the 24 years since 1991.**
- The hole formed more slowly this year, because the polar vortex was so symmetric around the pole – later solar exposure of the perturbed chemical region. The hole is slowly declining this year because of the weak dynamical forcing.
- While the current ozone hole area is large, this area is consistent with our understanding of ozone depletion chemistry and weaker than average stratospheric dynamical (weather) conditions. This "weak" dynamics colder than average stratospheric temperatures – which strongly modulates ozone depletion.



Average size of the Antarctic ozone hole derived from daily estimates between Sep. 7 and Oct. 13 of each year. The surface area of N. America is 24.7 M km^2 (red line). 2015 is the 4th largest ozone hole.



Oct 2, 2015 False-color view of total ozone over the Antarctic pole. The purple and blue colors are where there is the least ozone, and the yellows and reds are where there is more ozone.

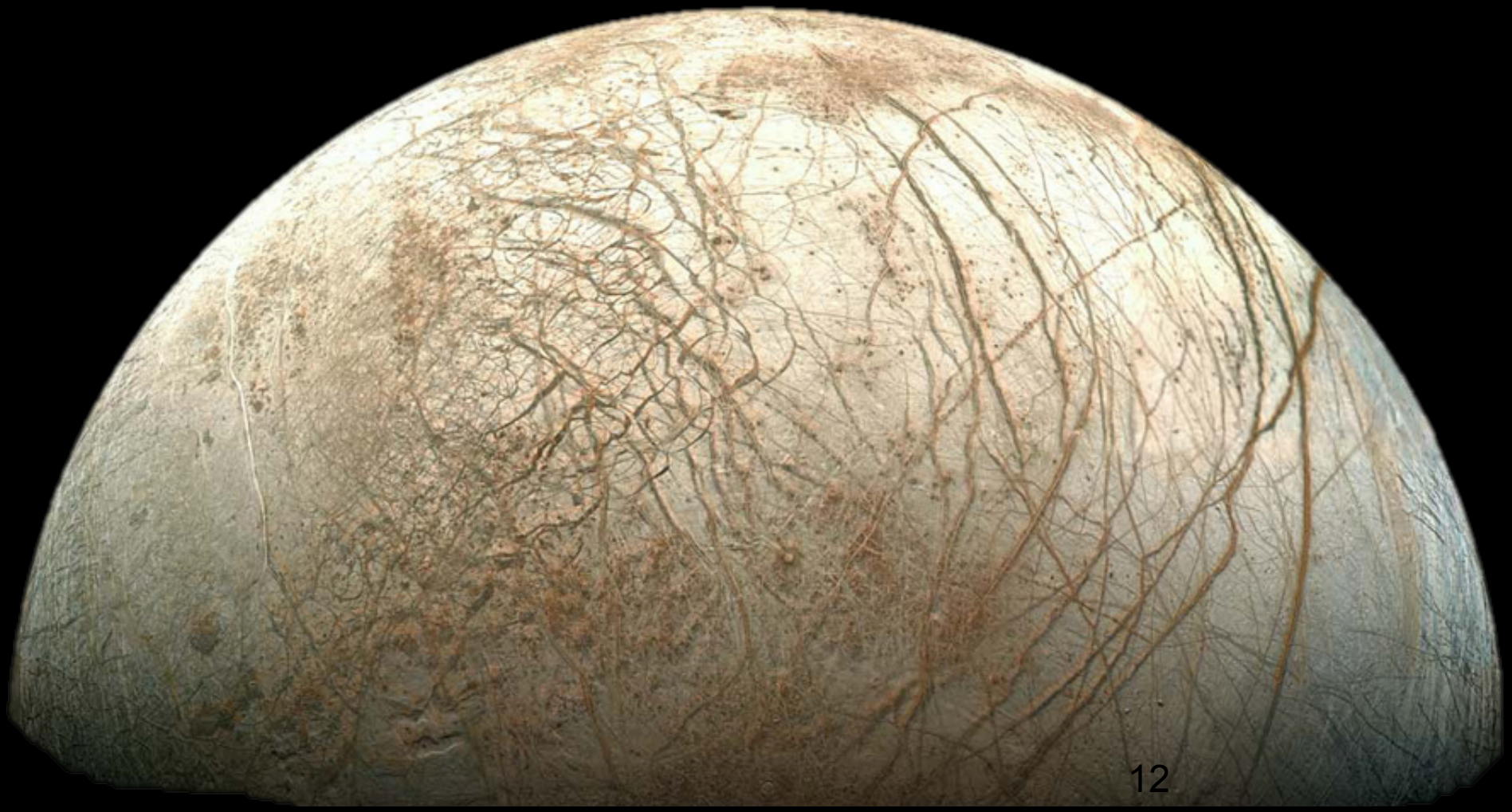
2015 Arctic Sea Ice Summertime Minimum Is Fourth Lowest on Record

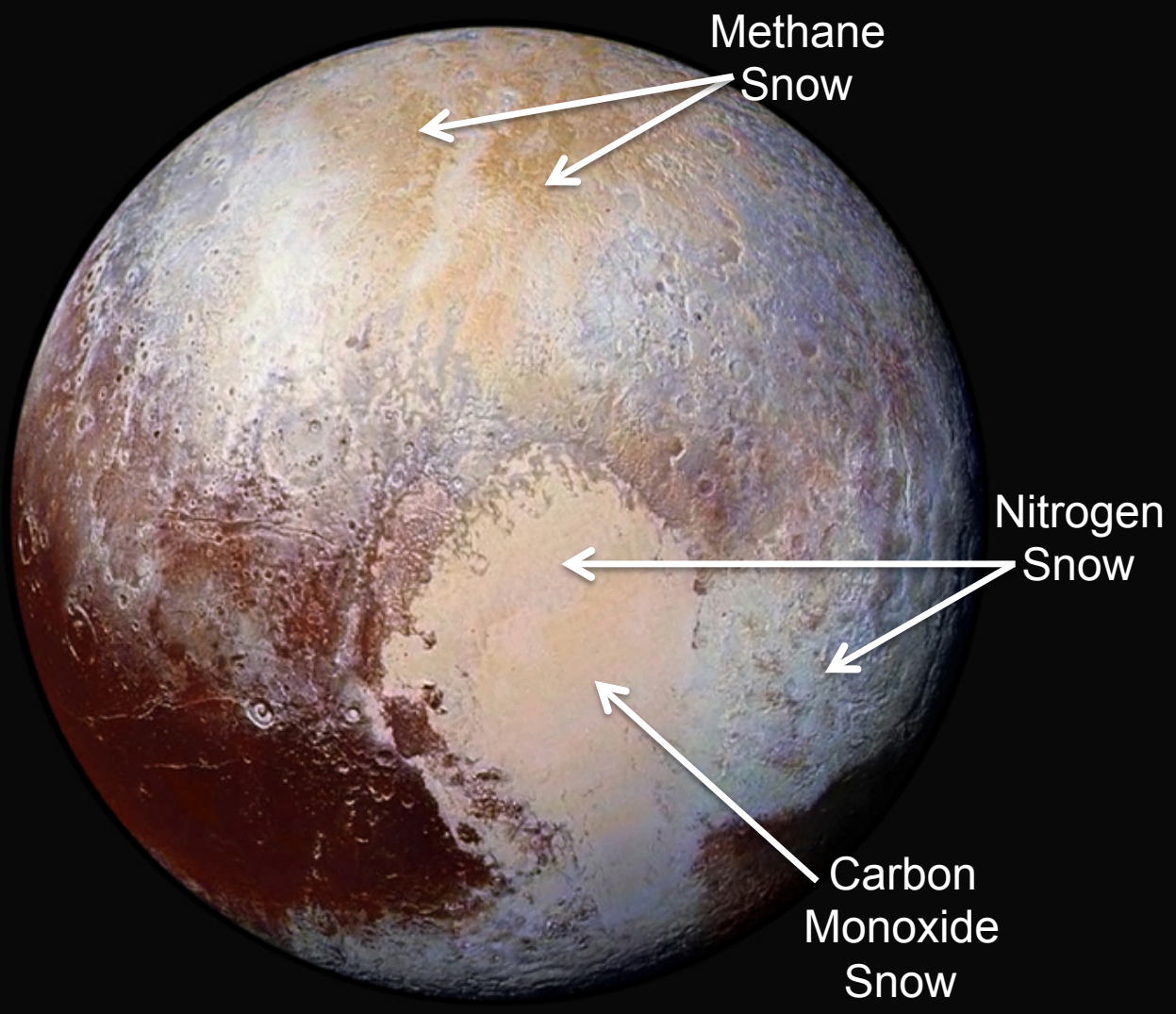
- **Analysis by NASA and NASA-supported National Snow and Ice Data Center (NSIDC) showed the annual minimum extent was 1.70 million square miles on Sept. 11. This year's minimum is 699,000 square miles lower than the 1981-2010 average.**
- Sea ice decline has accelerated since 1996. The 10 lowest minimum extents in the satellite record have occurred in the last 11 years.
- The 2014 minimum was 1.94 million square miles, the seventh lowest on record.

- This year, the **Arctic sea ice cover experienced relatively slow rates of melt in June**, which is the month the Arctic receives the most solar energy.
- However, **the rate of ice loss picked up during July, when the sun is still strong. Faster than normal ice loss rates continued through August**, a transition month when ice loss typically begins to slow.
- **A big "hole" appeared in August in the ice pack in the Beaufort and Chukchi seas, north of Alaska, when thinner seasonal ice surrounded by thicker, older ice melted**. The huge opening allowed for the ocean to absorb more solar energy, accelerating the melt.

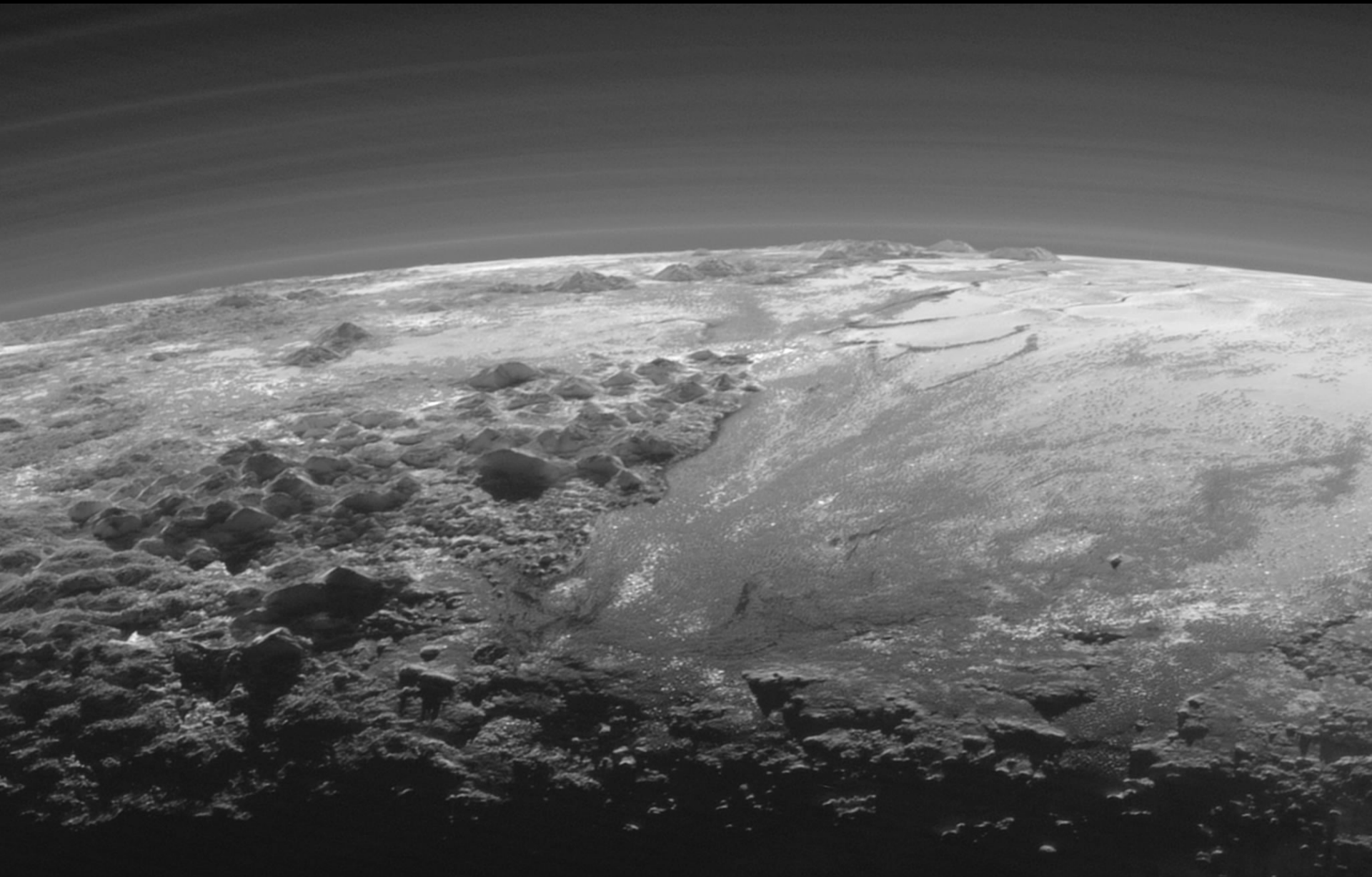
This animation shows the evolution of the Arctic sea ice cover from its wintertime maximum extent, which was reached on Feb. 25, 2015, and was the lowest on record, to its apparent yearly minimum, which occurred on Sept. 11, 2015, and is the fourth lowest in the satellite era. https://youtu.be/OpwM6PfcIbg

Planetary Science

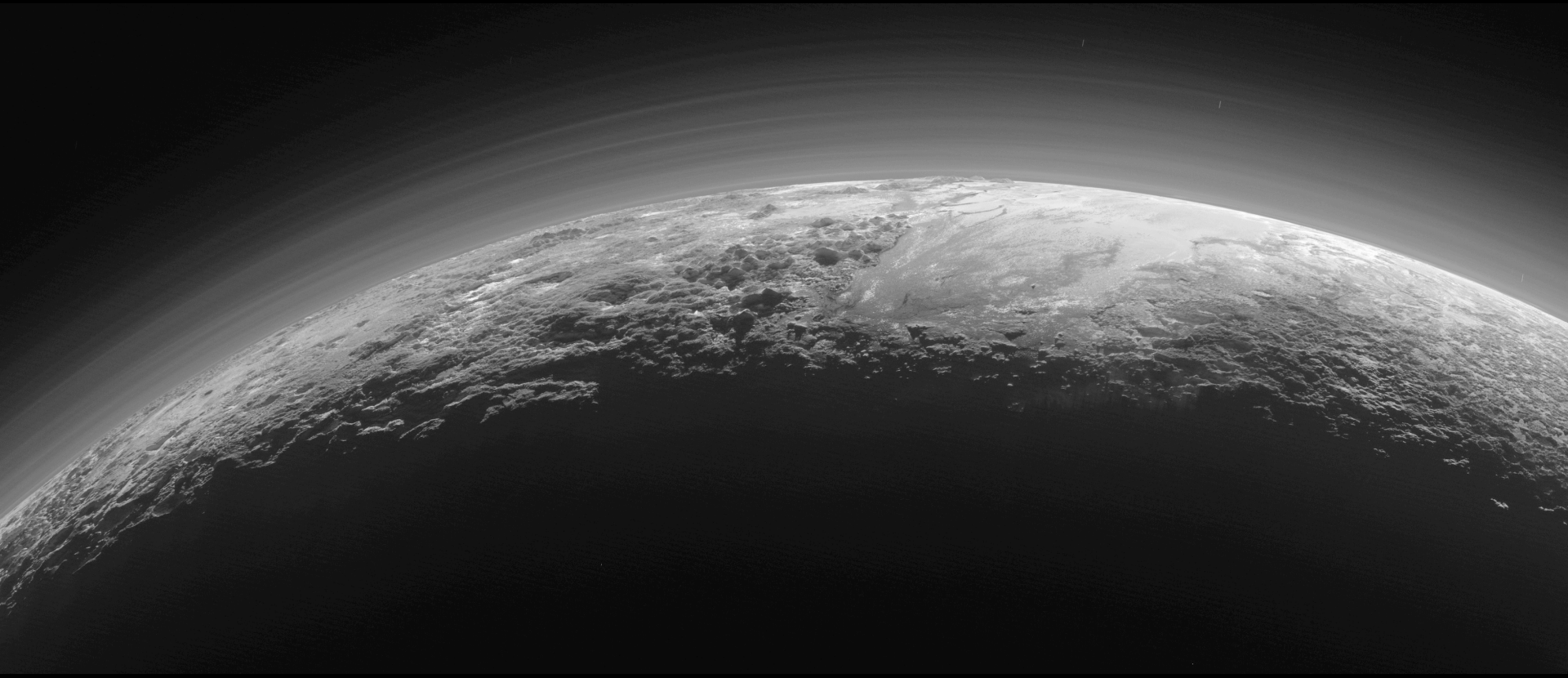



Methane
Snow
Nitrogen
Snow
Carbon
Monoxide
Snow

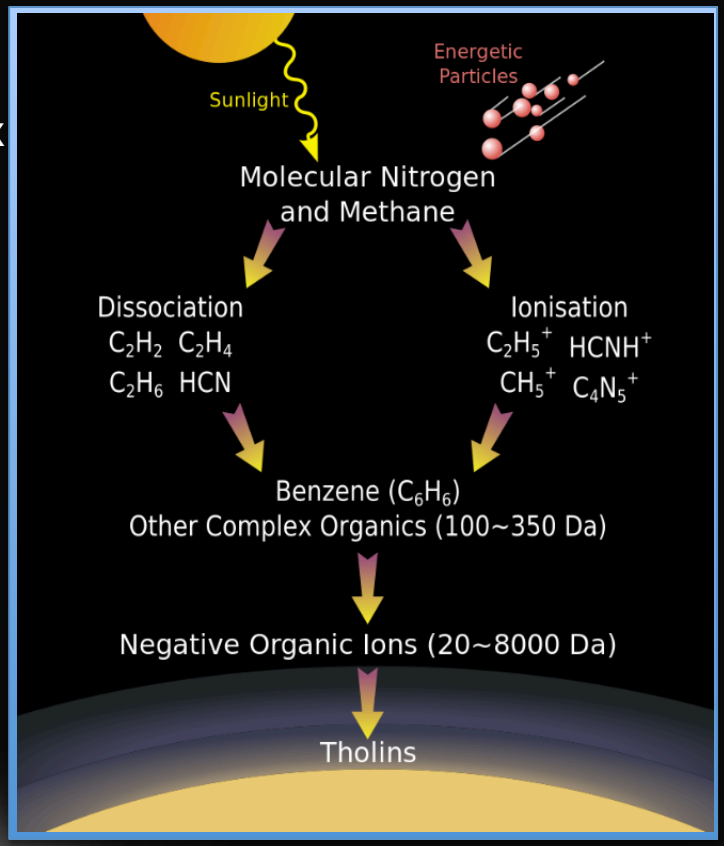
Majestic Mountains and Frozen Plains

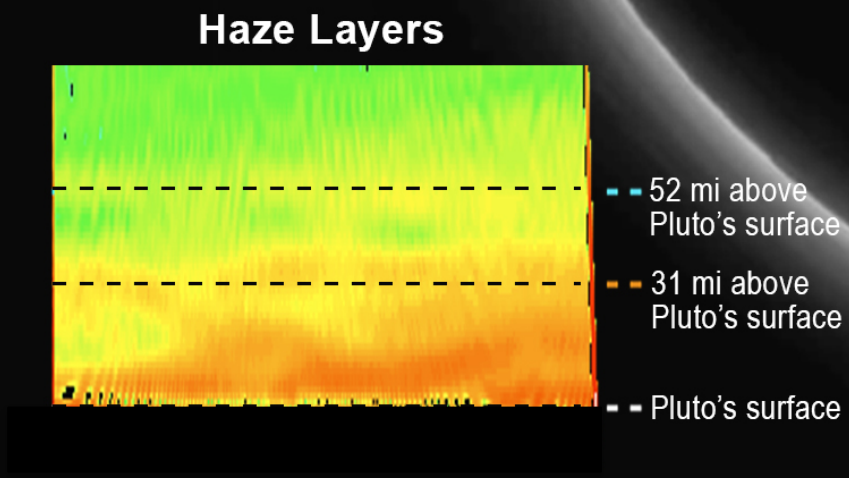


Pluto's Majestic Mountains, Frozen Plains and Foggy Hazes



Haze region where complex hydrocarbons (Tholins) are created?

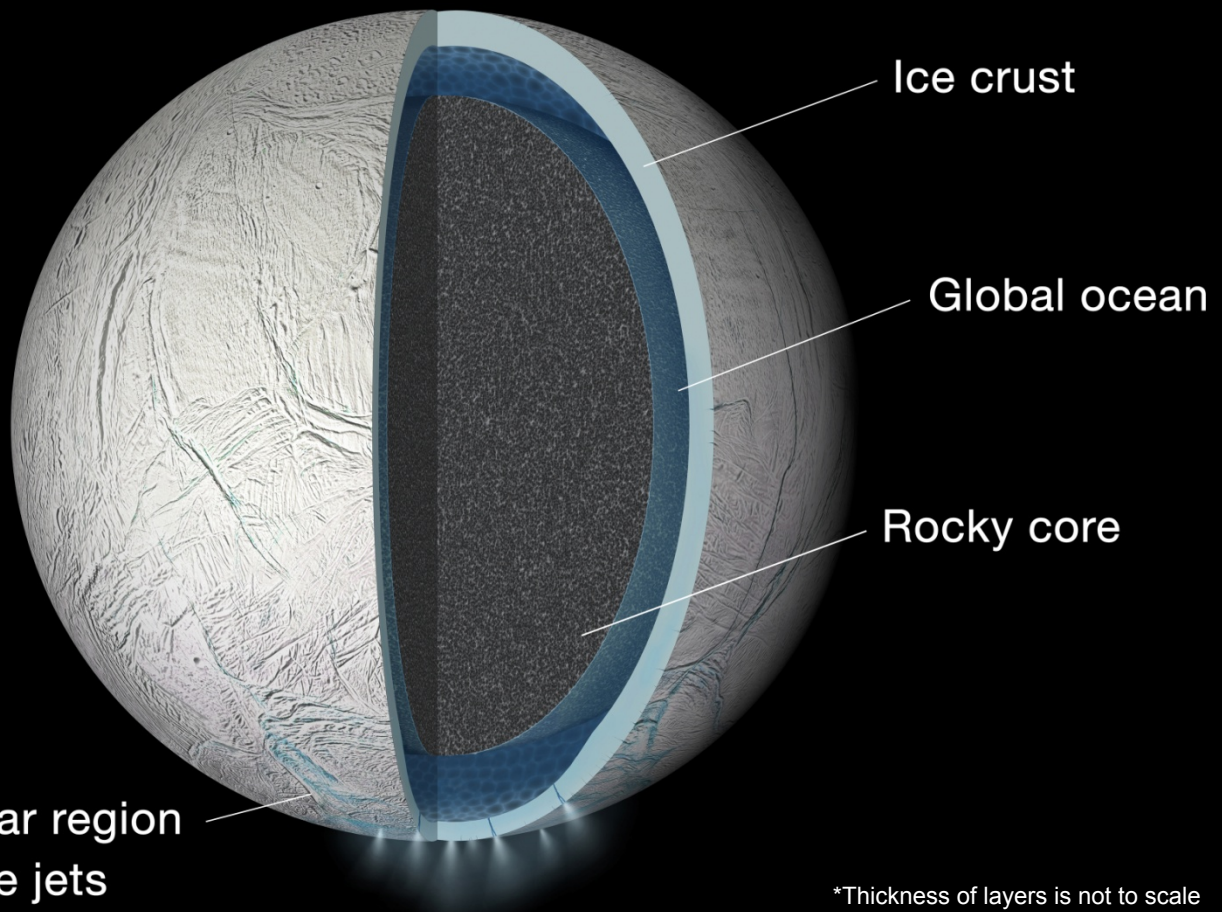




Global Ocean Inside Enceladus

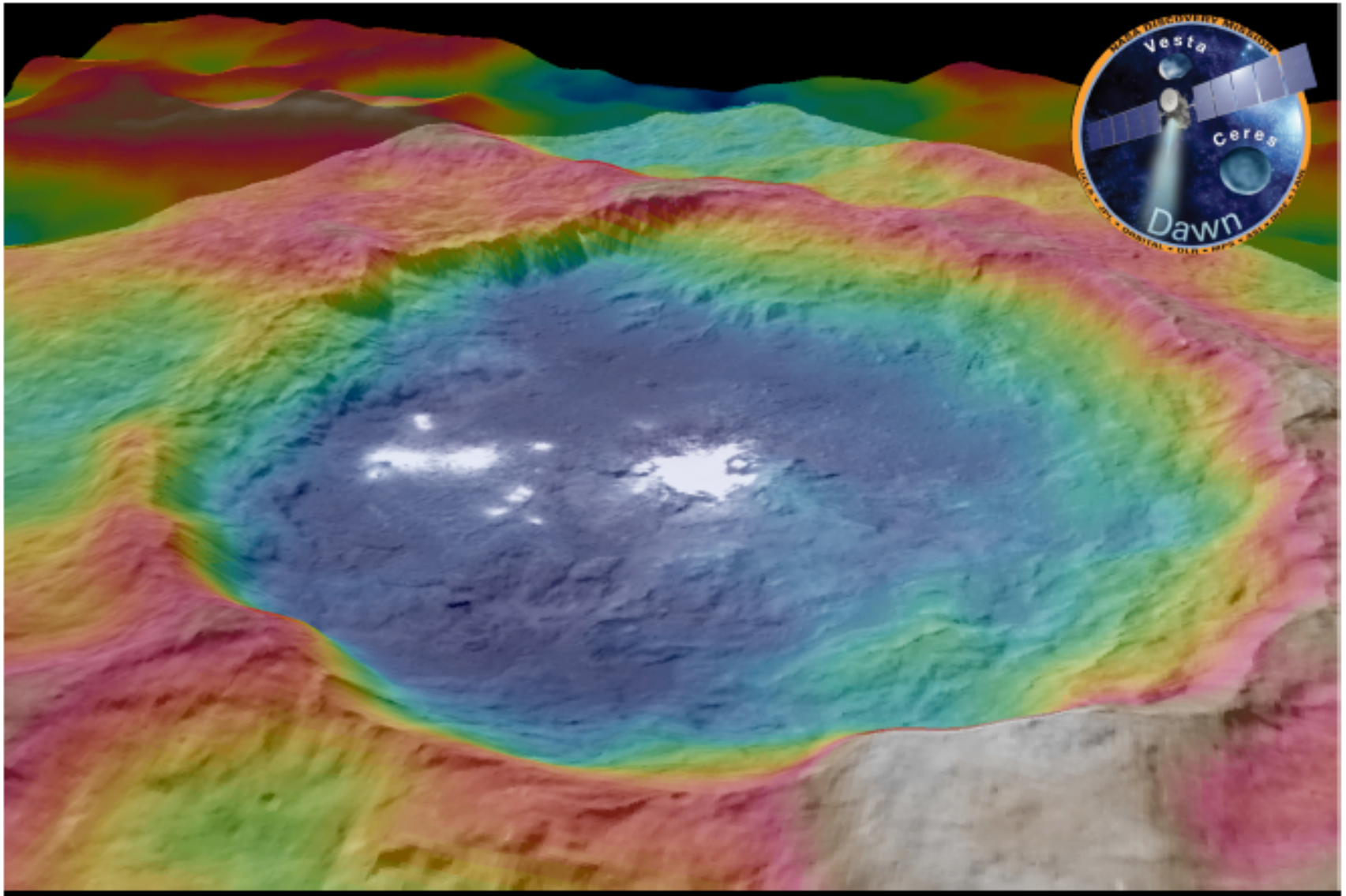
- Cassini imaging observations of Enceladus' rotation and its wobble (libration) as it orbits Saturn revealed the presence of a global ocean[1].
- Explaining the magnitude of the wobble requires a global ocean separating the outer ice shell from the interior. It rules out a completely frozen interior.
- A global ocean may mean that tidal flexing by Saturn's gravity generates much more heat inside Enceladus than previously thought.
- This discovery, together with this year's discovery of seafloor hydrothermal activity[2,3], indicates that ocean could be long-lived. Enceladus, the "ocean world," invites exploration.

Press Release - http://1.usa.gov/1NDHVlV



*Thickness of layers is not to scale

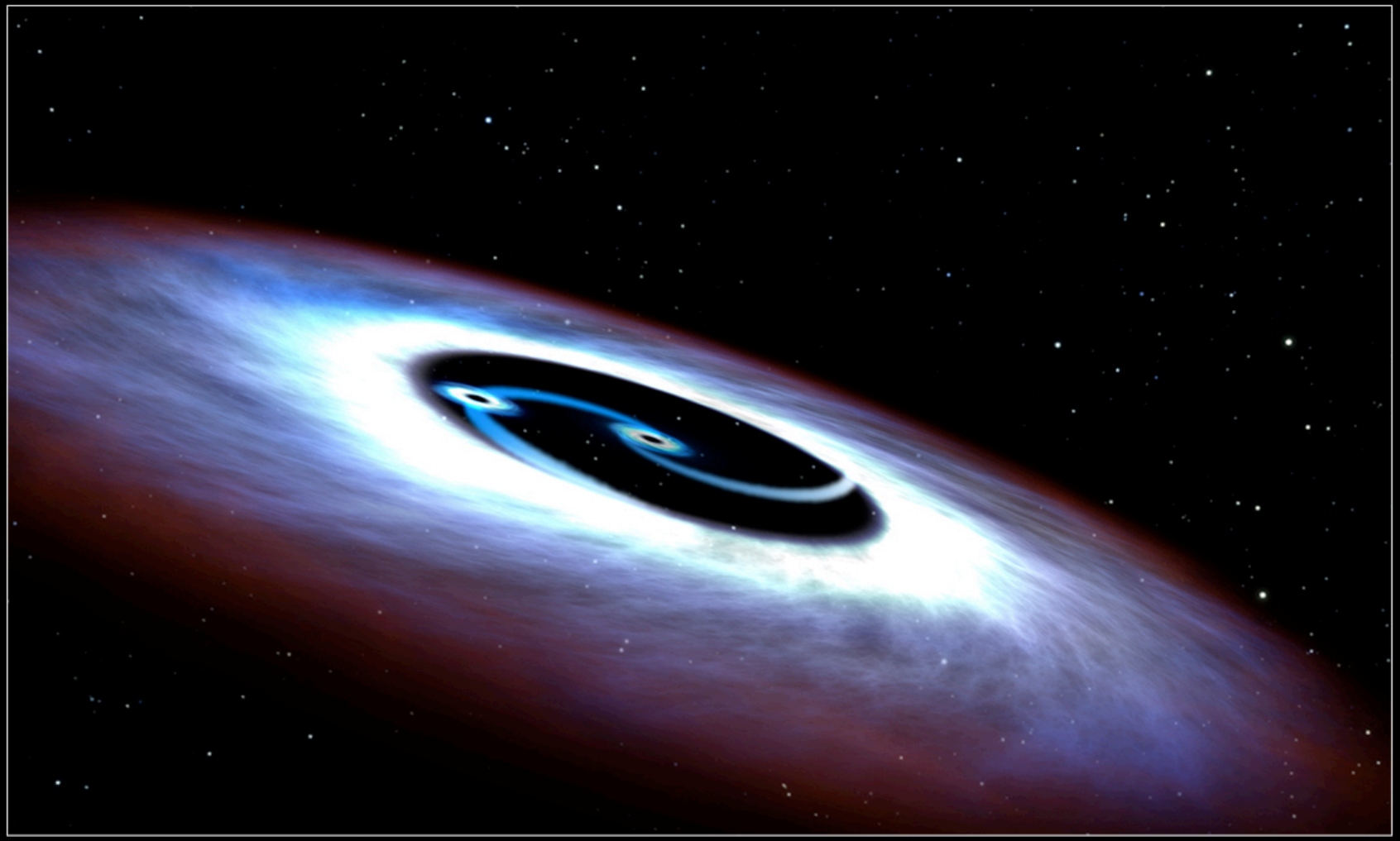
[1]*"Enceladus's measured physical libration requires a global subsurface ocean," P.C. Thomas, et al., 2015. doi:10.1016/j.icarus.2015.08.037*
[2]*"Ongoing hydrothermal activities within Enceladus," Hsu et al., Nature, 519, 207-210, 2015.*
[3]*"Possible evidence for a methane source in Enceladus' ocean ," Bouquet et al., Geophysical Research Letters, 42, 1334-1339, 2015.*



Mysterious bright spots in Ceres' 92-km Occator crater may be salt deposits from the interior.


National Aeronautics and Space Administration
NASA
Astrophysics

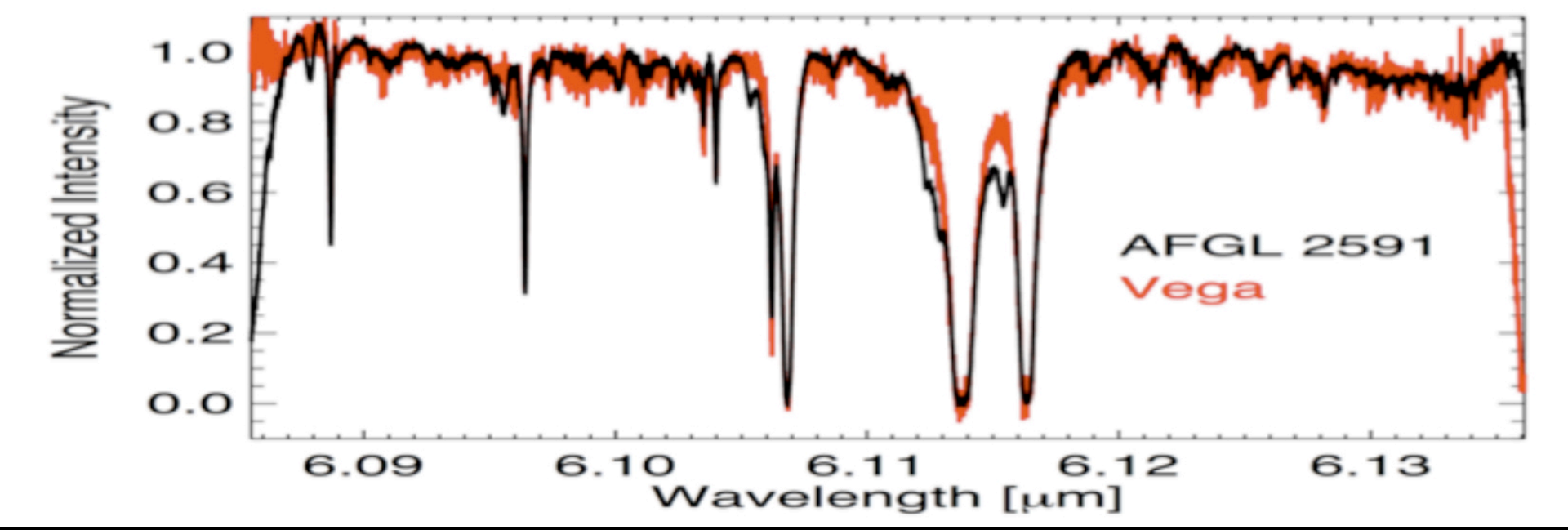
Hubble Finds That the Nearest Quasar is Powered by a Double Black Hole



Artist's View of a Binary Black Hole

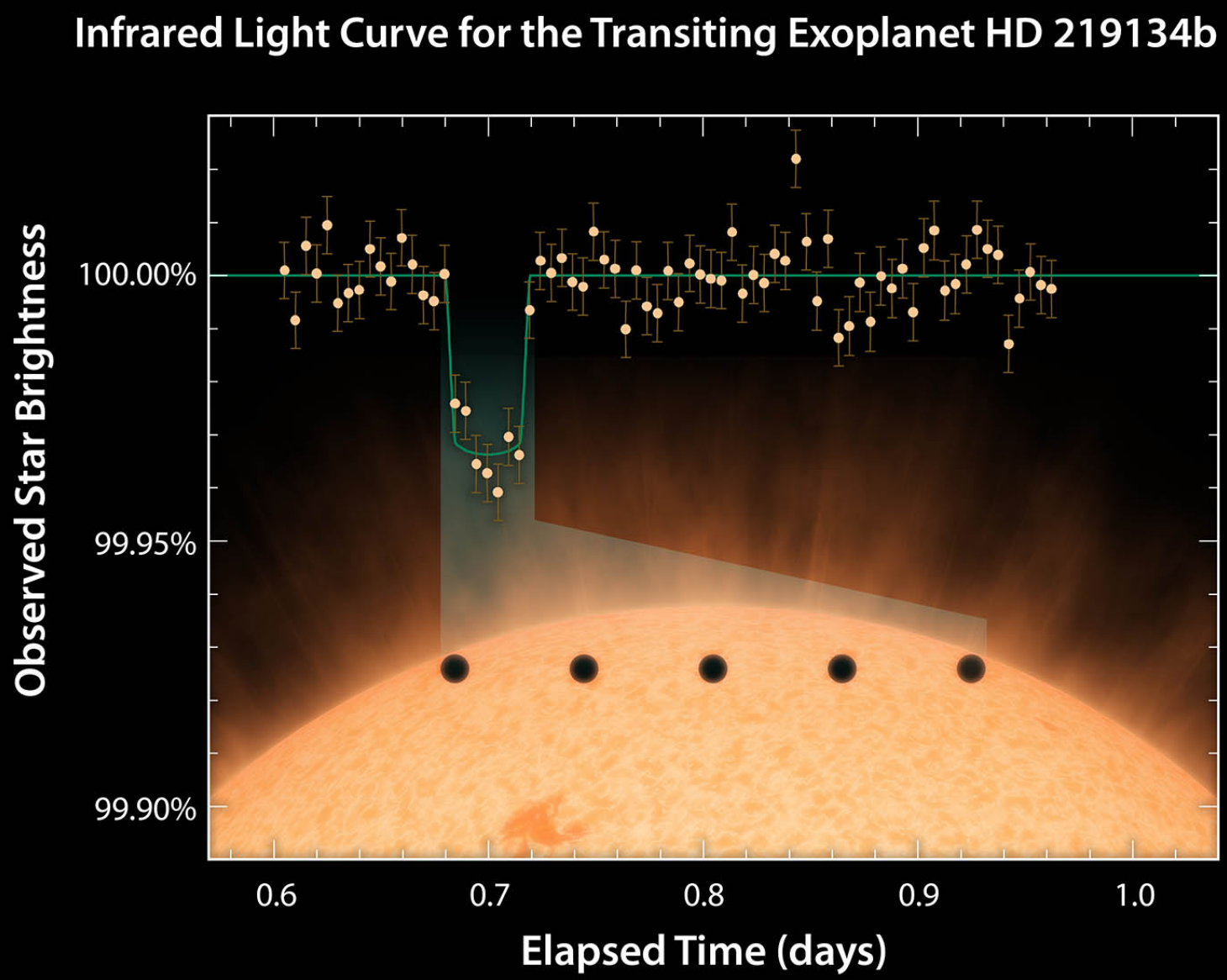
NASA and ESA ▪ STScI-PRC15-31a

SOFIA observes Water Around the Protostar AFGL 2591



Credit: indriolo et al.

Spitzer Confirms Closest Rocky Exoplanet

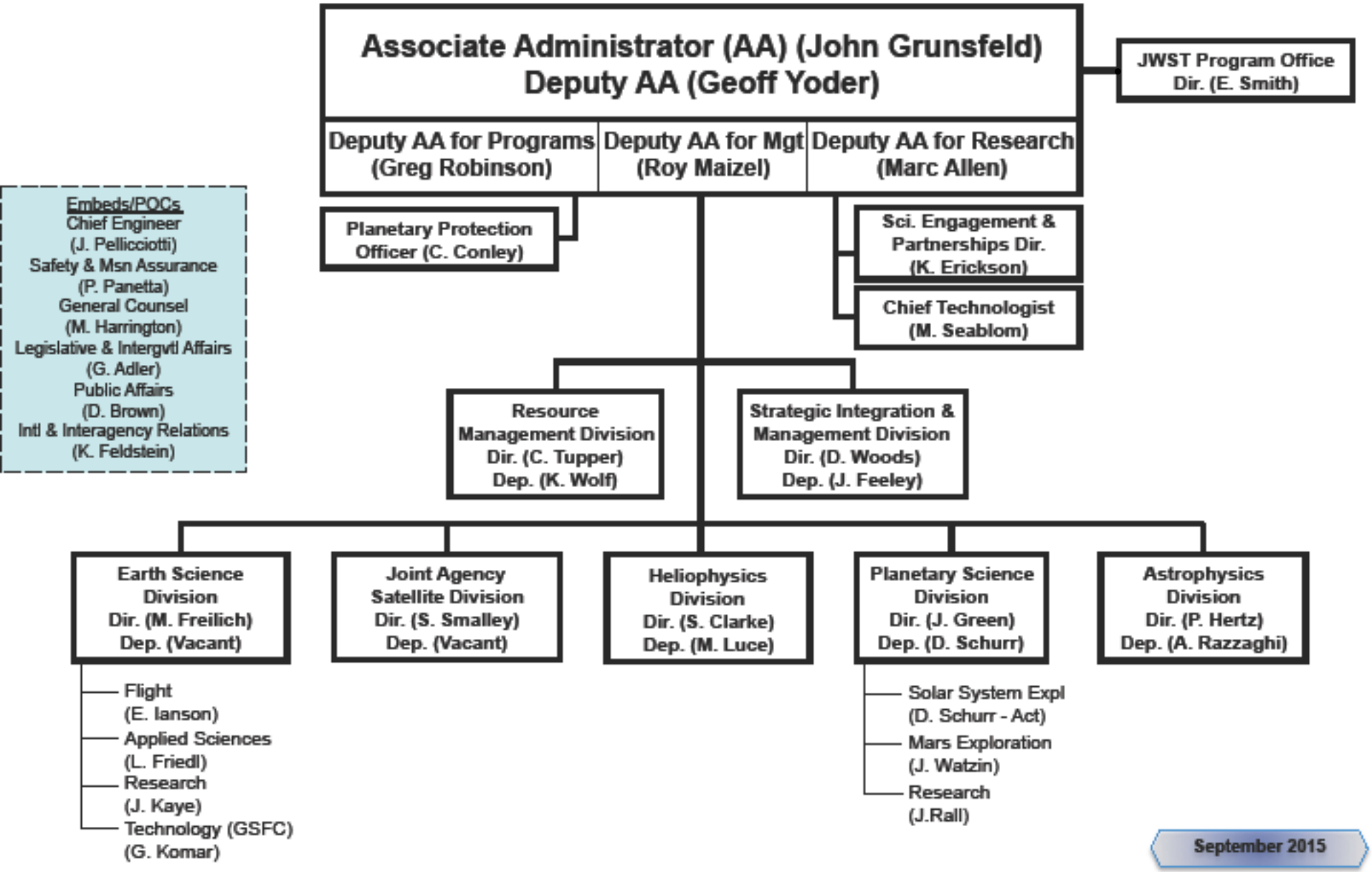


Credit: NASA/JPL-Caltech

Outline

- Science Results
- **Programmatic Status**
  - Heliophysics
  - Earth Science
  - Planetary Science
  - Astrophysics
  - Other Reports

SMD Organization

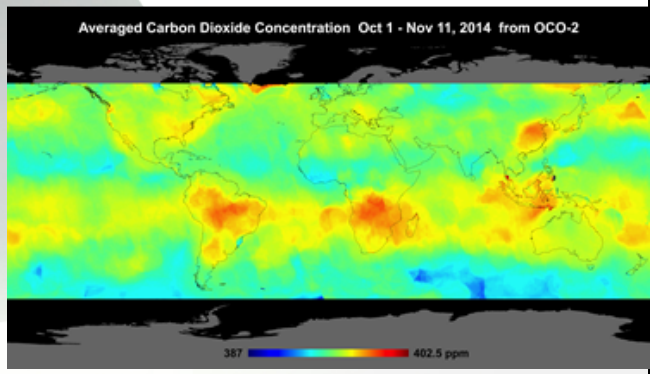


September 2015

NAC SC Subcommittee Highlights/Efforts In Work

Earth Science Subcommittee (ESS)

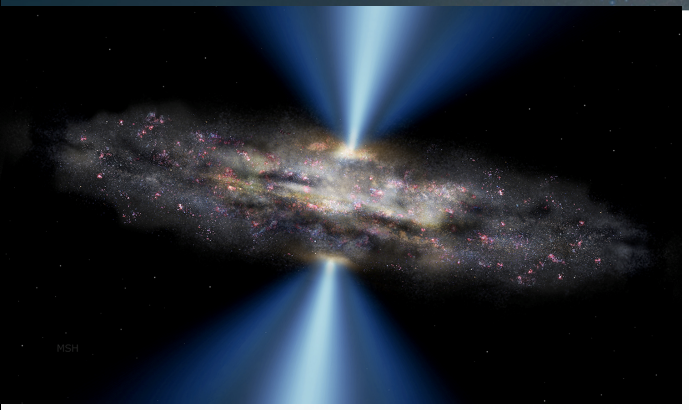
- **Meeting focused on Earth Systems modeling, with reports by key large-scale modeling groups and centers. Noted that Earth systems modeling based on global observations (atmosphere, oceans, land, ice) is a unique NASA capability, no other U.S science agency produces global satellite based datasets for this modeling. In the last 15 years NASA SMD ESD has deployed an unprecedented constellation of Earth observing satellites, and the data processing/archiving/distribution system to exploit the science.**
- **Finalizing its ideas to send forward on areas such as land modeling and global carbon modeling; and on practices such as coordinated model development and utilizing advanced computing power.**



Heliophysics Subcommittee (HPS)

- **On the competitive use of Payload Adapter Fittings (PAFs), HPD Director Clarke offered that HPD staff will take on the task of developing an assessment about PAF capabilities that will be distributed at the HPS, and as interest warrants, to the NAC SC, when complete. The HPS gladly accepted this offer.**

NAC SC Subcommittee Highlights/Efforts In Work



Astrophysics Subcommittee (APS)

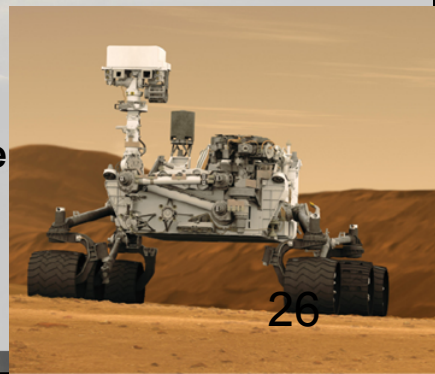
- All four astrophysics large mission concepts should be studied: FAR IR Surveyor, Habitableu Exoplanet Imaging Mission (HabEx), UV/Optical/IR Surveyor, and X-ray Surveyor.
- APS examined proposal pressure problem, and posited that a decline in Guest Observer funding is causing researchers to turn to grants for supp ort.

Planetary Science Subcommittee (PSS)

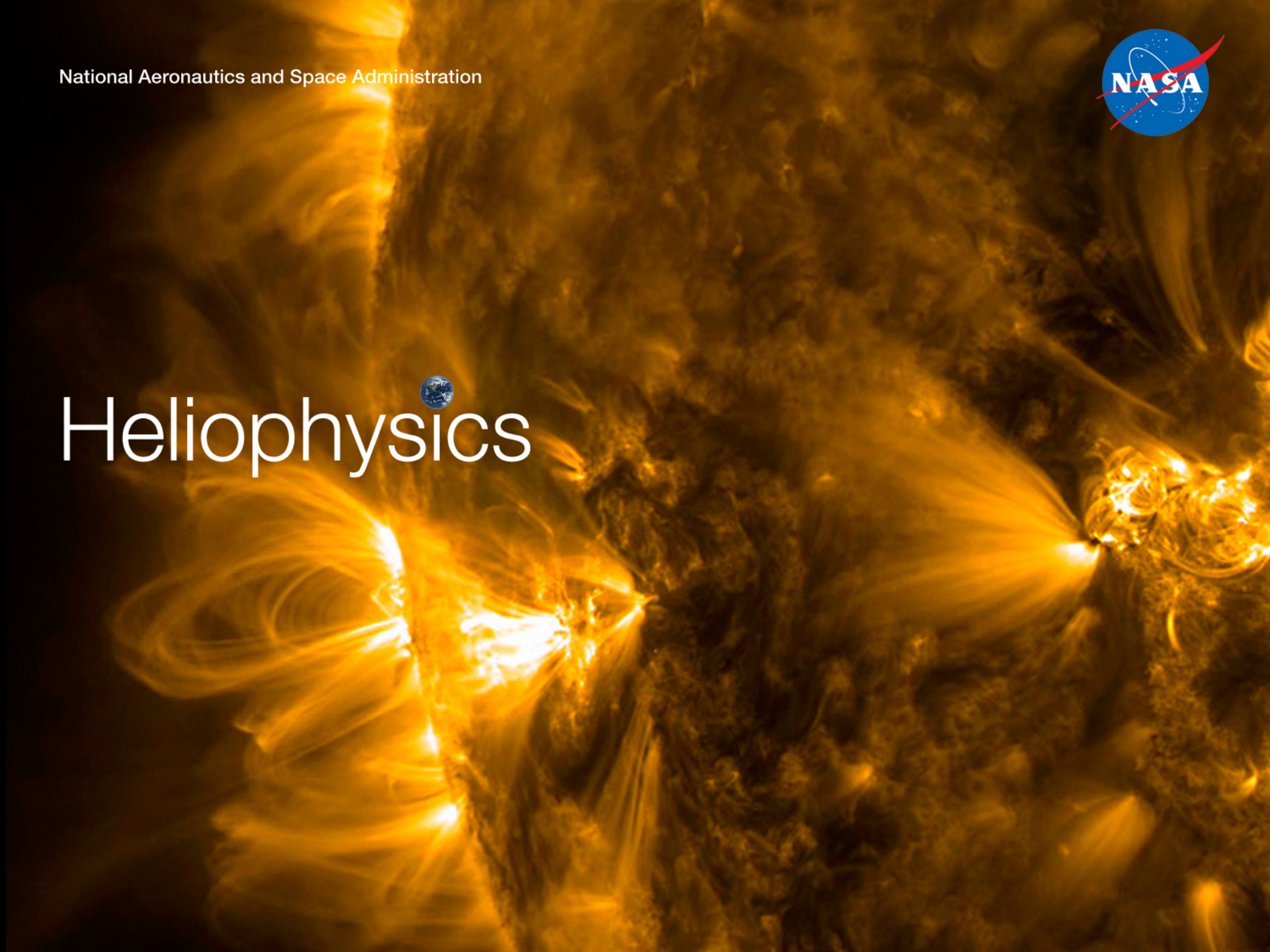
- Briefed on the NexSS (NASA exoplanet Systems Science), an R&A Program element that was formed from competitive proposals submitted to ROSES solicitations in all of the disciplines that formed a complementary set of investigations addressing the breadth of exoplanet systems research.
- Focus on R&A cadence the work of assessment groups.
- Interest in hearing more on a Mars 2022 orbiter.

Planetary Protection Subcommittee (PPS)

- Subgroup of Members joined the European Space Agency (ESA) Planetary Protection Working Group (PPWG) meeting in Madrid and gathered information about technical aspects (e.g. space system standards for Europe, synergistic sample return technologies, and studies of bioload on spacecraft). Learned the results of the Committee on Space Research (COSPAR) draft policies on Mars special regions and icy moons with liquid water. Members also had the opportunity to tour the Deep Space Network facility.
- The full PPS will deliberate on these topics at its December 8-9 meeting.



National Aeronautics and Space Administration



Heliophysics

Mission Rankings

All of the missions reviewed by the Senior Review Panel have been recommended for continued operations.

Science Ranking

	Median	Std Dev
IBEX	9	1.6
IRIS	9	1.3
Van Allen	9	1.5
AIM	8	1.2
Hinode	8	1.2
RHESSI	8	1.0
STEREO (2)	8	1.2
TIMED	8	1.2
Voyager	8	1.6
ACE	7	1.5
SDO	7	1.5
STEREO (1)	7	1.4
THEMIS	7	1.8
TWINS	7	1.3
Wind	7	1.2
CINDI	7	1.2

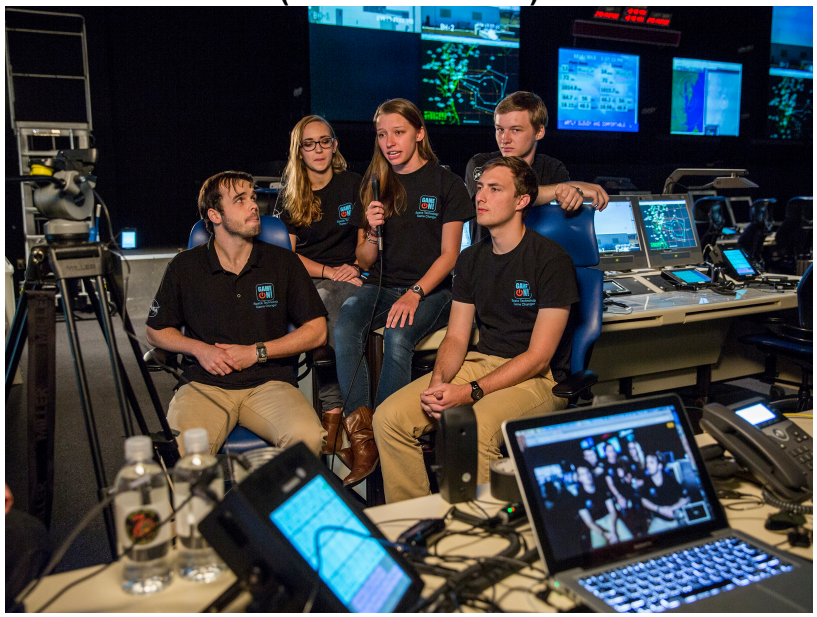
Heliophysics System Observatory Contribution Ranking

	Median	Std Dev
ACE	9	1.9
SDO	9	1.5
Hinode	9	1.8
IBEX	8	1.2
IRIS	8	1.2
STEREO (2)	8	1.1
THEMIS	8	1.3
Wind	8	1.3
RHESSI	8	1.6
STEREO (1)	8	1.5
Voyager	7	1.6
AIM	7	1.3
TIMED	7	1.9
TWINS	7	1.3
Van Allen	7	1.4
CINDI	6	1.2

Sounding Rockets Highlights

- **Hesh Mission – Successful launch from Wallops Flight Facility on 7 October**
  - Successfully demonstrated the new Black Brant MkIV rocket motor. Performance was nominal with no evidence of combustion instability. (NASA will continue to monitor the Black Brant motor performance for some time until the risk is fully retired.)
  - Delivered two technology demonstration experiments sponsored by STMD Game Changing Development

Langley Interns Watch Tech They Worked on Go to Space (and Come Back)



Eight NASA Langley interns worked on payloads that launched aboard a Black Brant IX sounding rocket from Wallops Flight Facility Oct. 7.
Credits: NASA/David C. Bowman

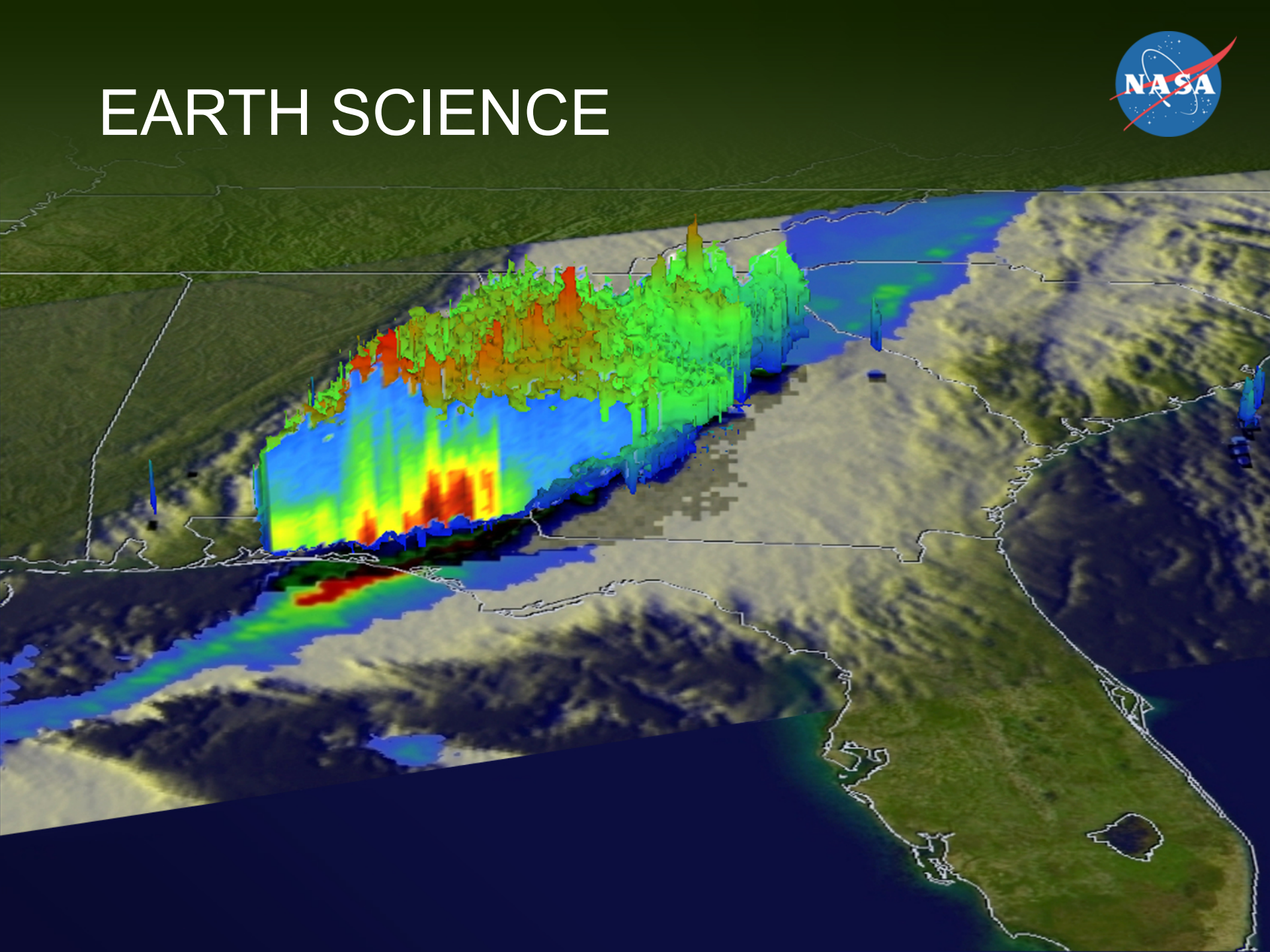
Black Brant Mk IV on Launch Rail

Representatives from NASA and Orbital ATK examine the Black Brant the day before launch.
Credits: NASA/David C. Bowman

National Space Weather Strategy

- The Office of Science Technology Policy (OSTP), Executive Office of the President, led the multi-agency effort to develop a National Space Weather Strategy (NSWS), which was officially released on 29 October.
- The NSWS articulates strategic goals for improving forecasting, impact evaluation, and enhancing National Preparedness (protection, mitigation, response and recovery) to a severe space weather event.
- A Space Weather Action Plan (SWAP) has been developed to establish cross-Agency actions, timelines and milestones for the implementation of the NSWS.
- The Action Plan will:
  - Enhance the transition of research to operations for space weather observations, modeling tools, advance warning capabilities and mitigation approaches
  - Incorporate severe space weather events in Federal emergency preparedness, planning, scenarios, training, and exercises
  - Establish Federal and non-Federal stakeholder collaborations to enhance observing systems and networks and data management activities

EARTH SCIENCE



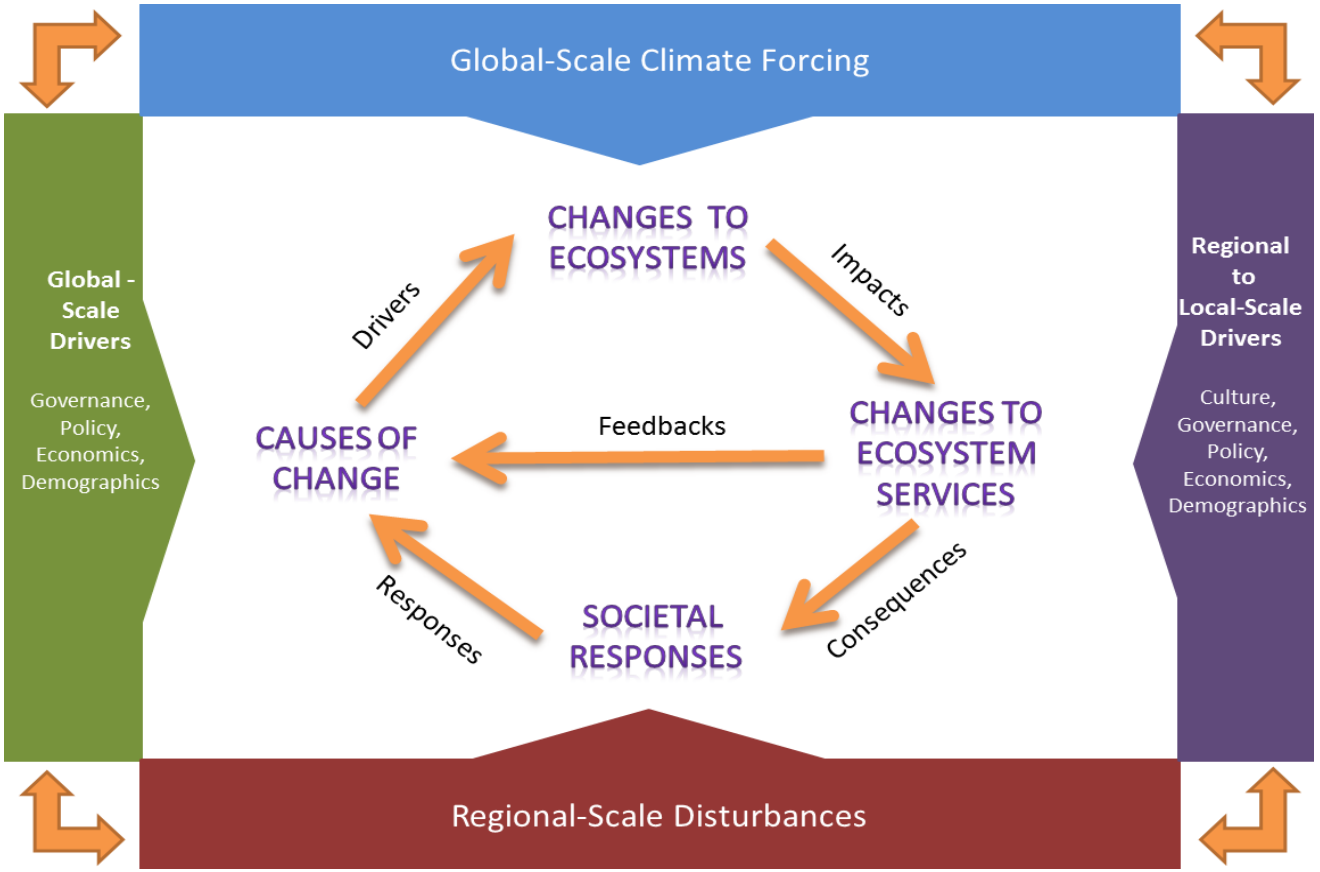
Venture Class Launch Services (VCLS)

- Joint ESD/NASA Launch Services Program initiative
- RFP released 12 June 2015; Selections announced 14 Oct 2015
- Funded with $10M from ESD
  - Selected launches will:
    - Accommodate 132 pounds (60 kilograms) of CubeSats on 1 or more launches
    - Launch(es) must occur by April 15, 2018

- Selectees:
  - Firefly Space Systems, Inc.
  - Virgin Galactic LLC
  - Rocket Lab USA, Inc.

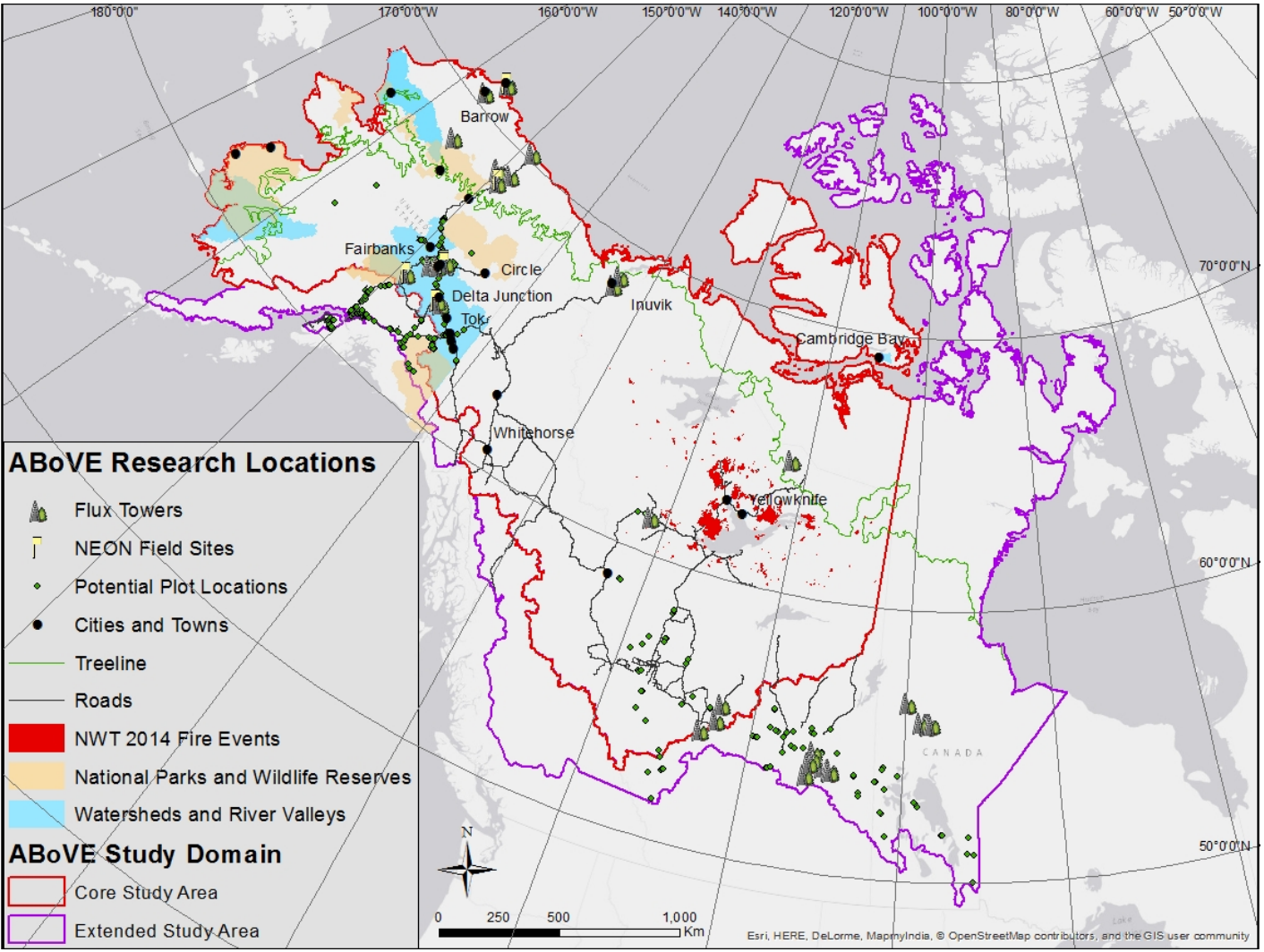
Tangible and substantial ESD investment in small launch vehicles

Conceptual Diagram of the Vulnerability/Resilience Framework Used for Organizing the ABoVE Science Questions and Objectives



ABoVE's Overarching Science Question:

How vulnerable or resilient are ecosystems and society to environmental change in the Arctic and boreal region of western North America?



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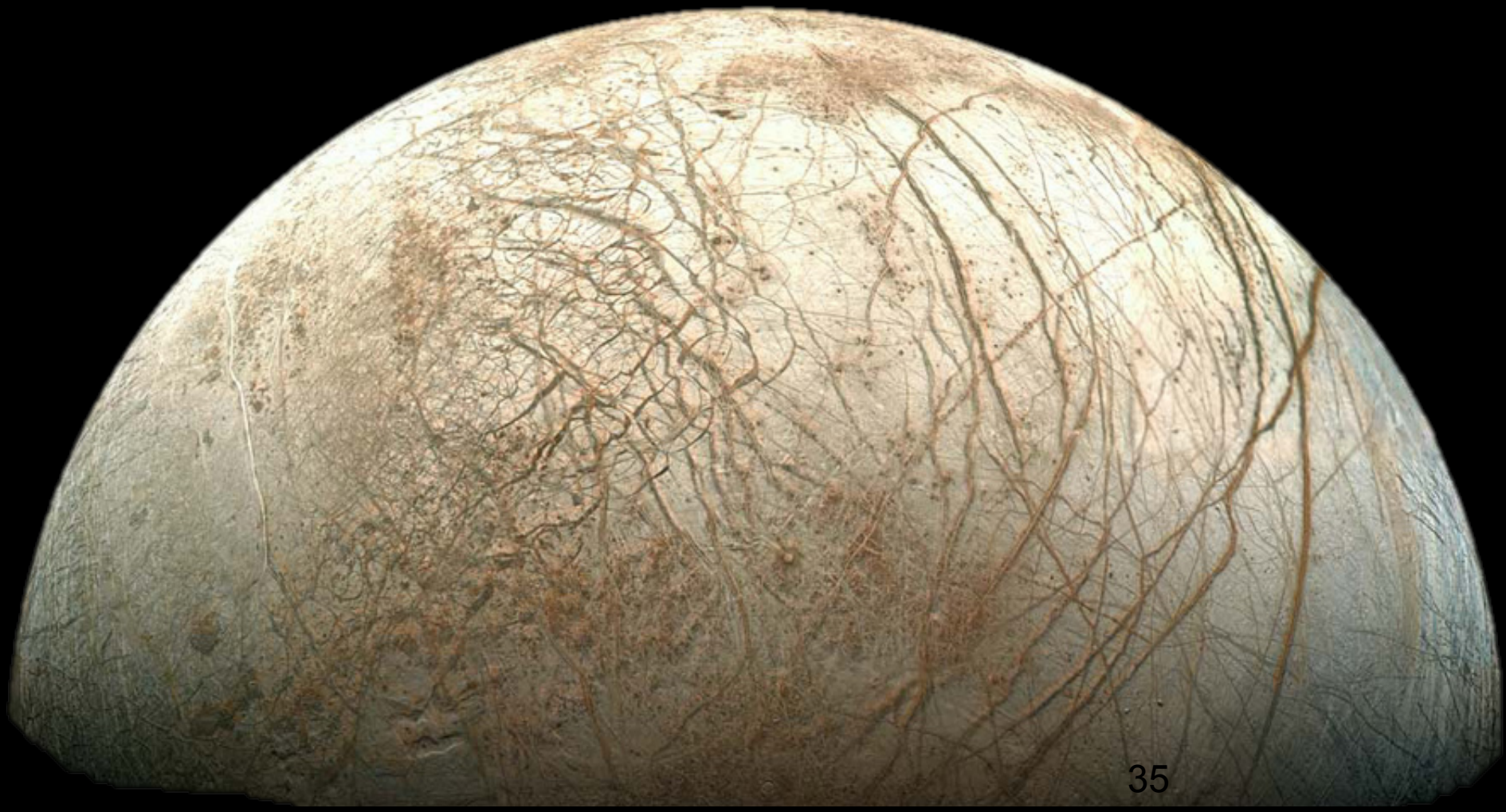
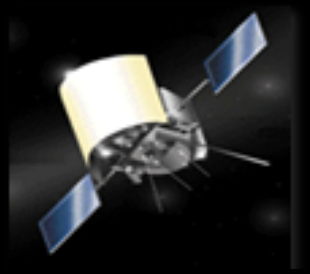
Planetary Science

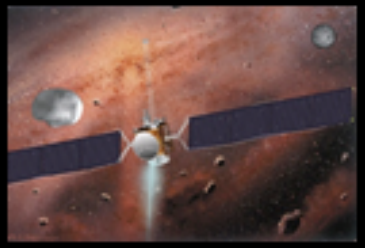


Status of Discovery Program

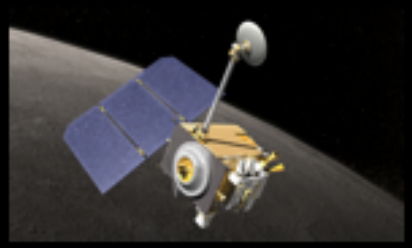
Mercury environment: MESSENGER (2004-*2015*)



Main-belt asteroids: Dawn (2007-*2016*)



Lunar surface: LRO (2009-*TBD*)



ESA/Mercury Surface: Strofio (*2016-TBD*)

Mars Interior: InSight (2016-*TBD*)

Missions in Development

- *InSight*: Launch window opens March 4, 2016 (Vandenberg)
- Strofio: Delivered to SERENA Suite (ASI) for BepiColombo

Missions in Operation

- *Dawn*: Science observations now in HAMO

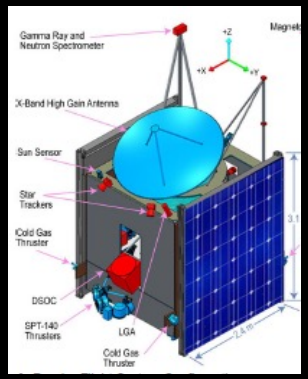
Missions in Extended Operations

- *MESSENGER*: Completed low altitude science operations before impact with Mercury
- *LRO*: In stable elliptical orbit, passing low over the lunar south pole

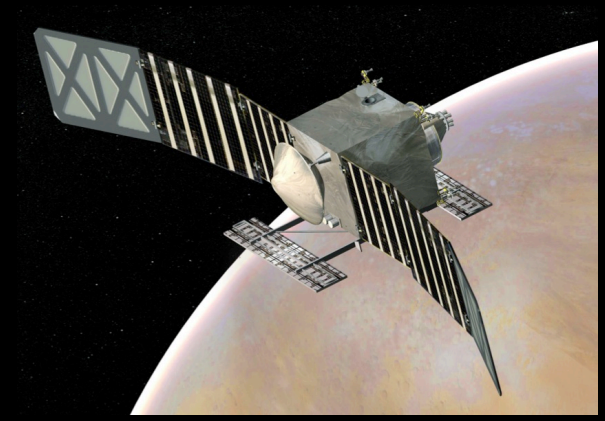
Discovery 2014 – Selections announced September 30

- About 3-year mission cadence for future opportunities

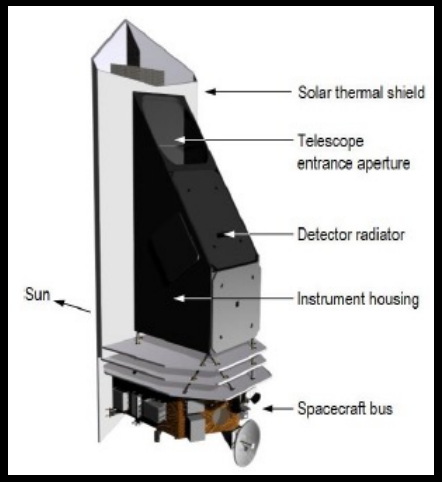
Discovery Selections



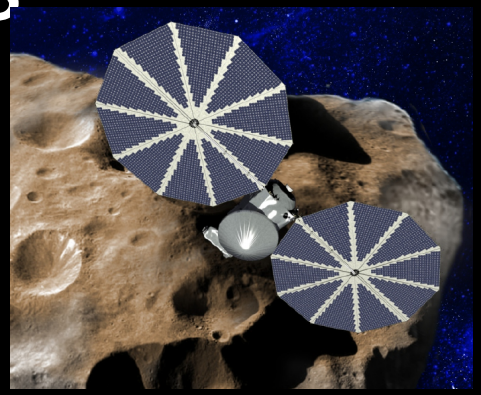
Psyche: Journey to a Metal World
PI: Linda Elkins-Tanton, ASU
Deep-Space Optical Comm (DSOC)



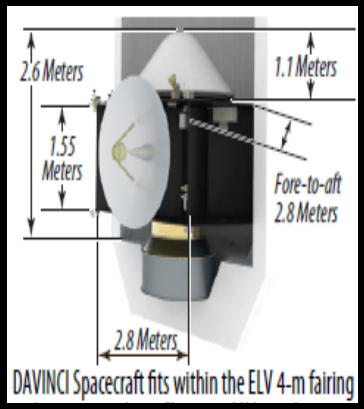
VERITAS: Venus Emissivity, Radio Science, InSAR, Topography, And Spectroscopy
PI: Suzanne Smrekar, JPL
Deep-Space Optical Comm (DSOC)

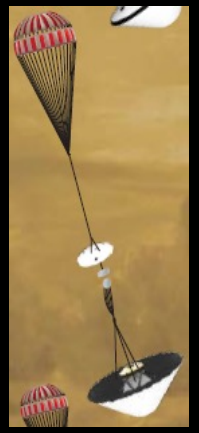


NEOCam:
Near-Earth Object Camera
PI: Amy Mainzer, JPL
Deep-Space Optical Comm (DSOC)



Lucy: Surveying the Diversity of Trojan Asteroids
PI: Harold Levison, Southwest Research Institute (SwRI)
Advanced Solar Arrays





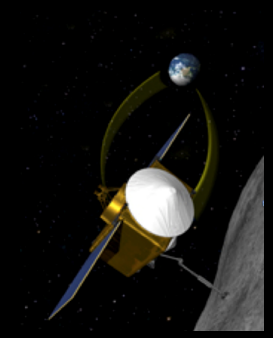
DAVINCI: Deep Atmosphere Venus Investigations of Noble gases, Chemistry, and Imaging
PI: Lori Glaze, GSFC

Status of New Frontiers Program

Next New Frontiers AO - to be released by end of Fiscal Year 2016

- New ROSES call for instrument/technology investments released

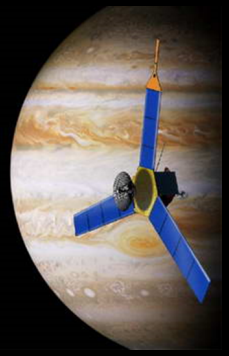
Missions in Development - OSIRIS REx



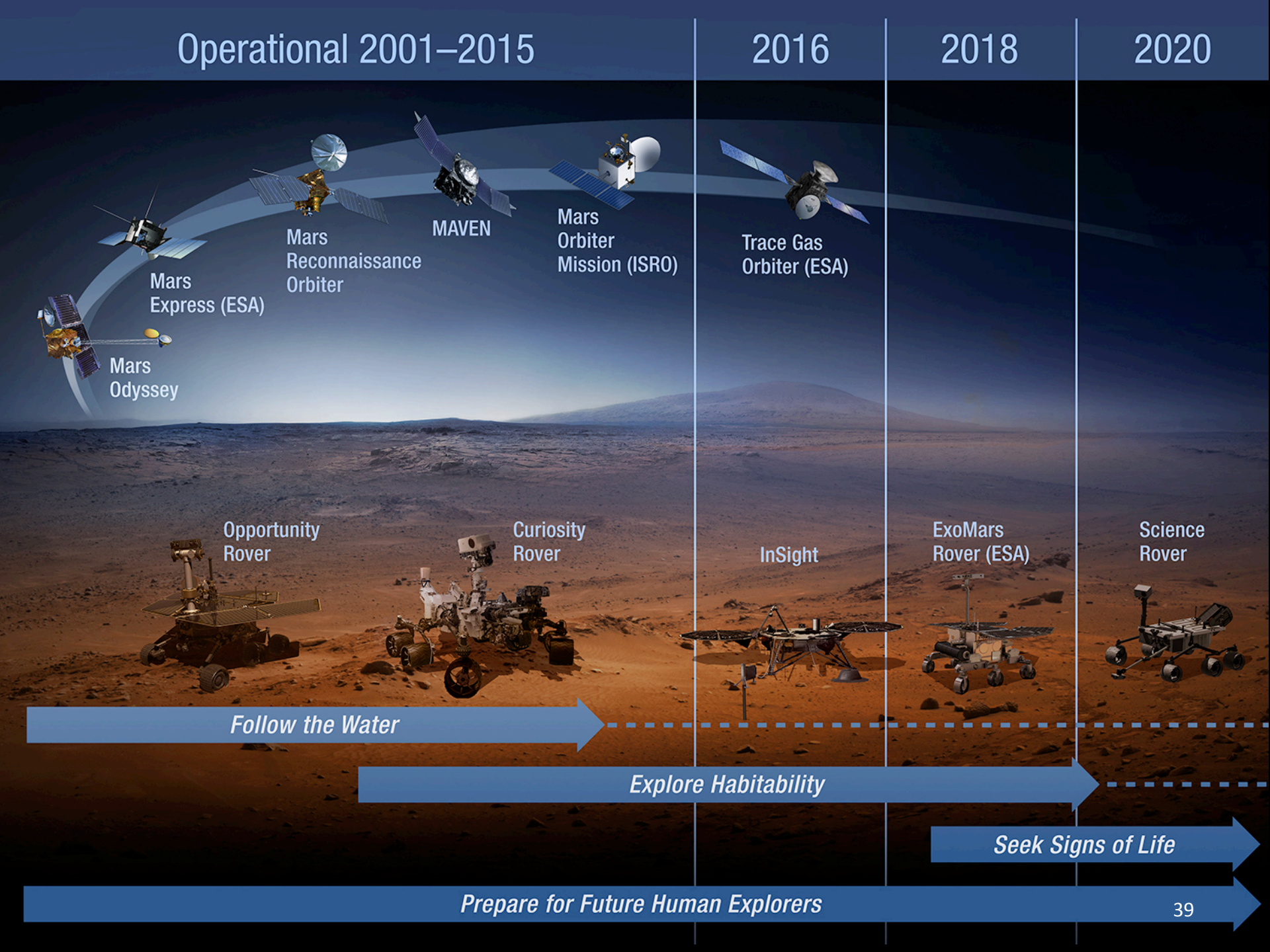
- Launch in Sept 2016 & encounter asteroid Bennu in Oct 2018.
- Operate at Bennu for over 400 days.
- Returns a sample in 2023 that scientists will study for decades with ever more capable instruments and techniques.

Missions in Operation

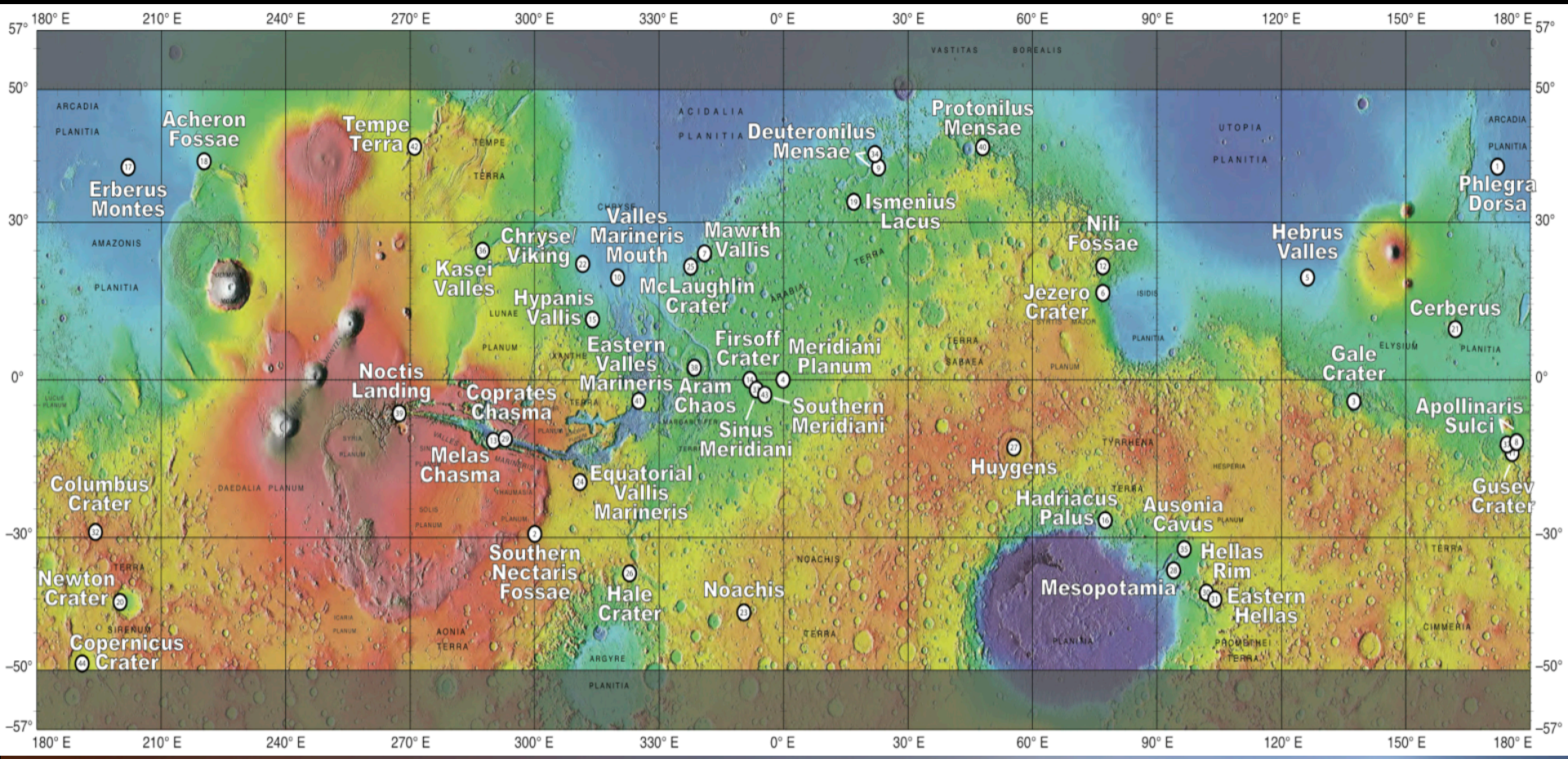
- New Horizons:
  - Pluto system encounter July 14, 2015
  - HST identified 2 KBO's beyond Pluto for potential extended mission
  - NH approved to target small Kuiper Belt object 2014 MU69



- Juno:
  - Spacecraft is 5.01 AU from the sun and 1.02 AU from Jupiter
  - Orbit insertion is July 4, 2016


Operational 2001–2015
2016
2018
2020
Mars Express (ESA)
Mars Odyssey
Mars Reconnaissance Orbiter
MAVEN
Mars Orbiter Mission (ISRO)
Trace Gas Orbiter (ESA)
Opportunity Rover
Curiosity Rover
InSight
ExoMars Rover (ESA)
Science Rover
Follow the Water
Explore Habitability
Seek Signs of Life
Prepare for Future Human Explorers

Potential Exploration Zones



1st Human Landing Site Workshop
October 27-30 at LPI

#JOURNEYTOMARS


National Aeronautics and Space Administration
NASA
Astrophysics

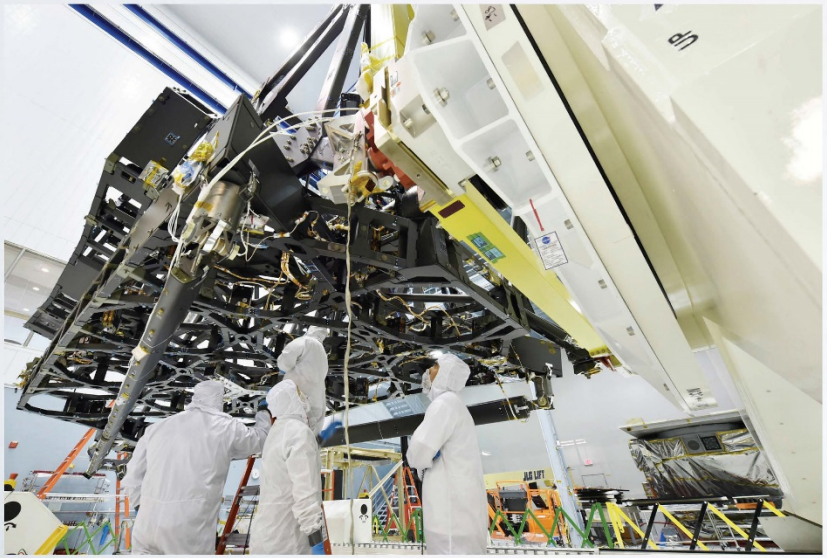
Astrophysics - Big Picture

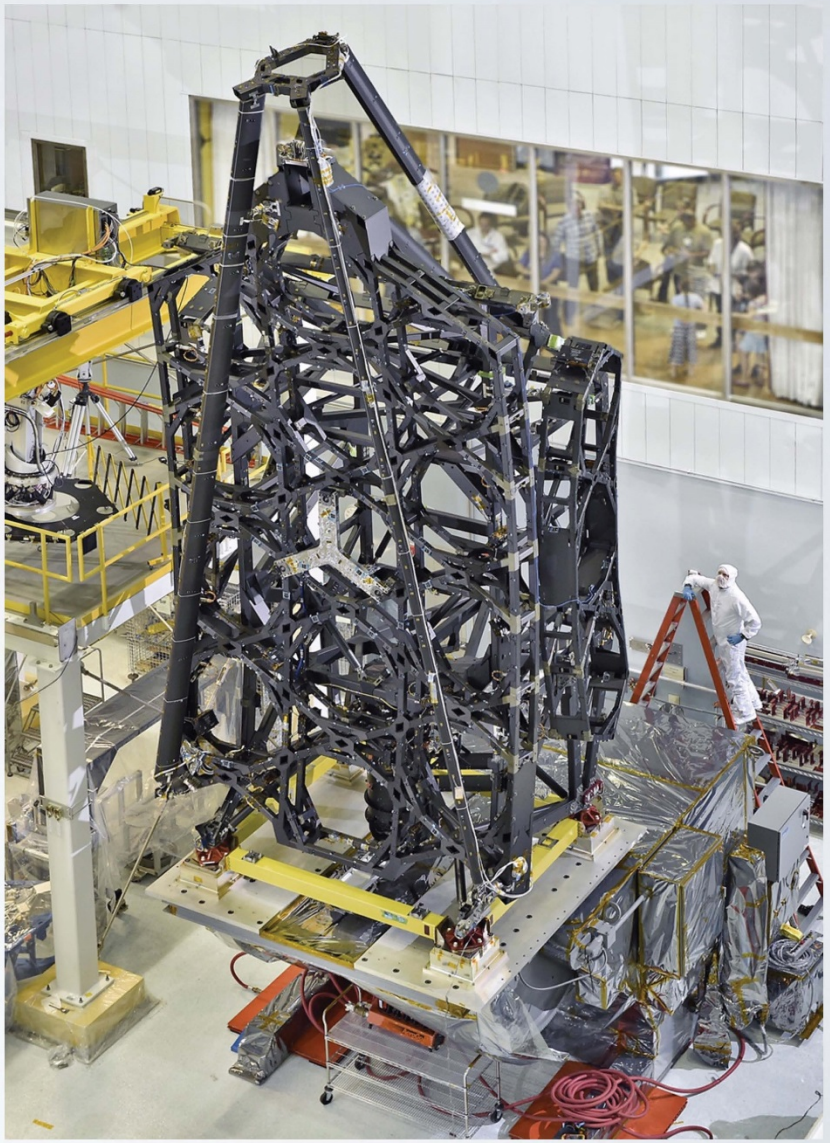
- **The FY16 budget request provides funding for NASA astrophysics to continue its programs, missions, and projects as planned**
  - The total funding (Astrophysics including JWST) is flat at ~$1.3B through FY20
  - Fully fund JWST to remain on plan for an October 2018 launch
  - Fund continued pre-formulation and technology work leading toward WFIRST; rate of progress depends on FY16 appropriation level
- **The operating missions continue to generate important and compelling science results, and new missions are under development for the future**
  - Chandra, Fermi, Hubble, Kepler/K2, NuSTAR, Spitzer, Swift, XMM-Newton all operating well; next Senior Review is Spring 2016 for FY17+; Suzaku mission ended
  - SOFIA is in prime operations as of May 2014; Senior Review is Spring 2018
  - Missions on track for launch include LISA Pathfinder (2015), ASTRO-H (2015/2016), ISS-CREAM (2016), NICER (2016), TESS (2017), JWST (2018), Euclid (2020)
  - WFIRST being studied, next Explorers being selected (SMEX in 2015, MIDEX in 2017), NASA joining ESA's Athena and ESA's L3 gravitational wave observatory
- **Progress being made against recommendations of the 2010 Decadal Survey**
  - Update to the Astrophysics Implementation Plan released in December 2014
  - NRC Mid Decade Review (with NSF, DOE) underway; Jackie Hewitt (MIT) is chair; report expected in May 2016
  - NASA initiating large mission concept studies as input for 2020 Decadal Survey
- **All ongoing work continuing under FY16 Continuing Resolution**

JWST Mission Status

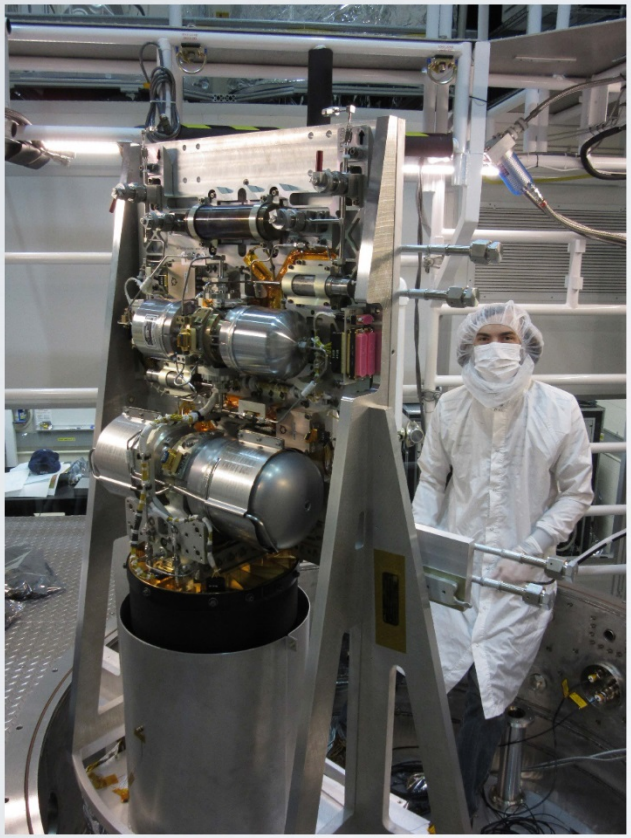
- Manufacturing coming to a close
  - 2 of 5 Sunshield layers finished, 3 others in fabrication
  - Flight spare cryocooler compressor assembly expected in February
- Many activities are deep into Integration and Test (I&T):
  - Telescope Structure delivered, optics integration starting soon
  - Pathfinder telescope + flight Aft Optics in 2nd cryo test
  - ISIM starting CV3 imminently
  - Spacecraft bus structure delivered to I&T
  - Flight cryocooler compressor assembly in acceptance testing
- Commissioning planning moving into high gear

TELESCOPE STRUCTURE

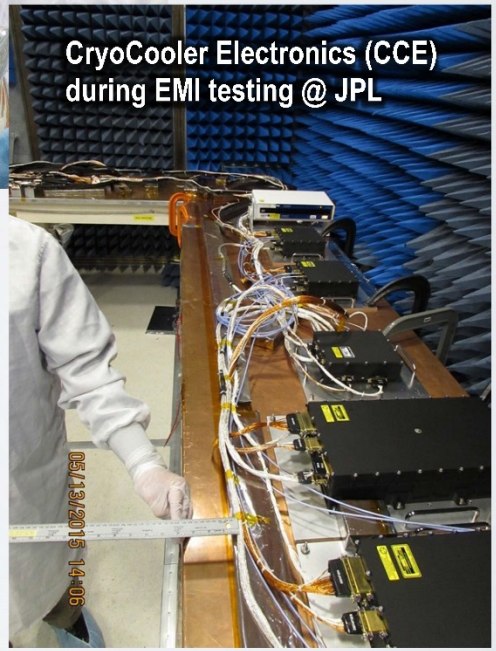




FLIGHT CRYOCOOLER



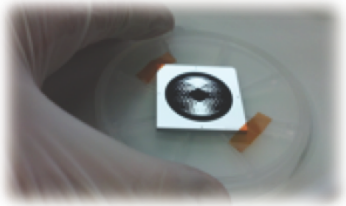
Compressor Assembly and deployable refrigerant line



Executive Summary

- Huge progress on WFIRST over the past two years
- SDT studies & NRC Harrison committee report confirm that WFIRST-AFTA exceeds NWNH requirements in all areas.
- $107M in FY14 & 15 has enabled major steps forward and NRC-Harrison committee recommendations have been addressed (H4RGs, coronagraph, mission design). Planning against $56M in FY16, exact amount depends on appropriations.
- Coronagraph on track, technology development on schedule. Wide Field detector technology development on schedule
- MCR scheduled for Dec 8-9. Prepared for start of formulation (KDP-A) as early as January 2016.
- SDT 2014 & 15 studies completed
- Preparatory Science teams selected
- Pasadena conferences held
- Special session at AAS's & IAU
- Science team NRA released
- Industry study RFIs received
- Significant international interest (Canada, ESA, Japan, Korea)

WFIRST H4RG-10



Shaped-Pupil Coronagraph Mask

AAAC Report

Selected Other Reports


A
1 km


MY 29
MY 30
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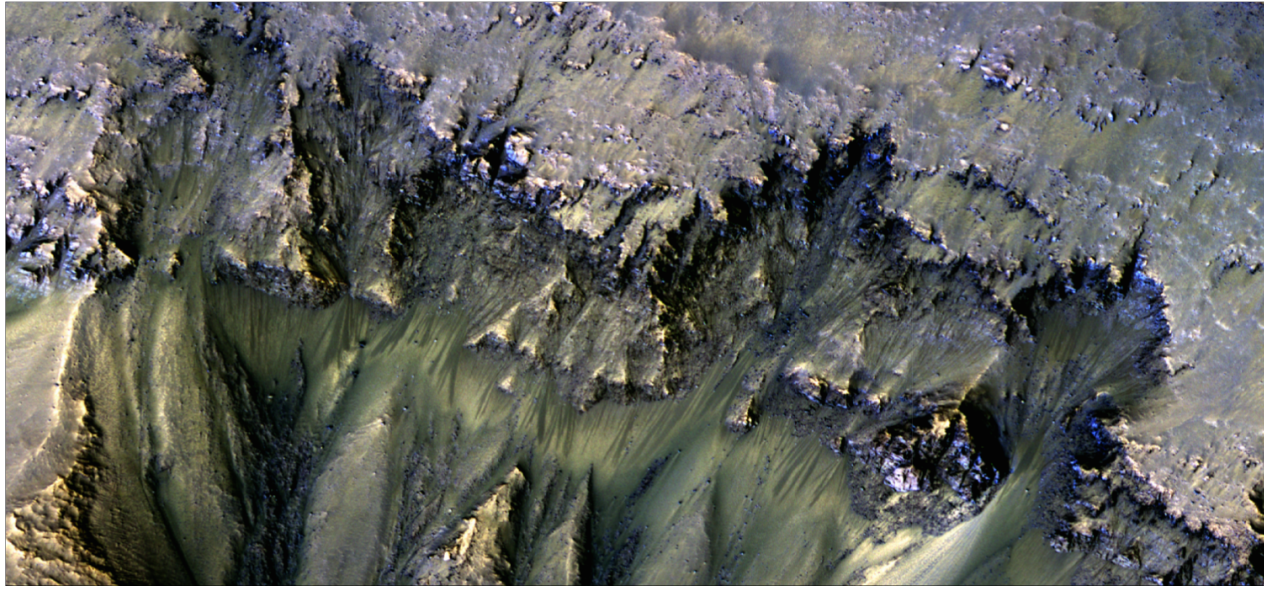
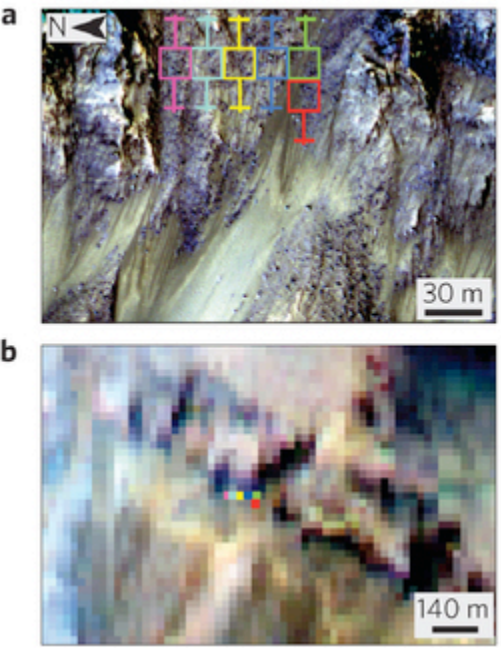
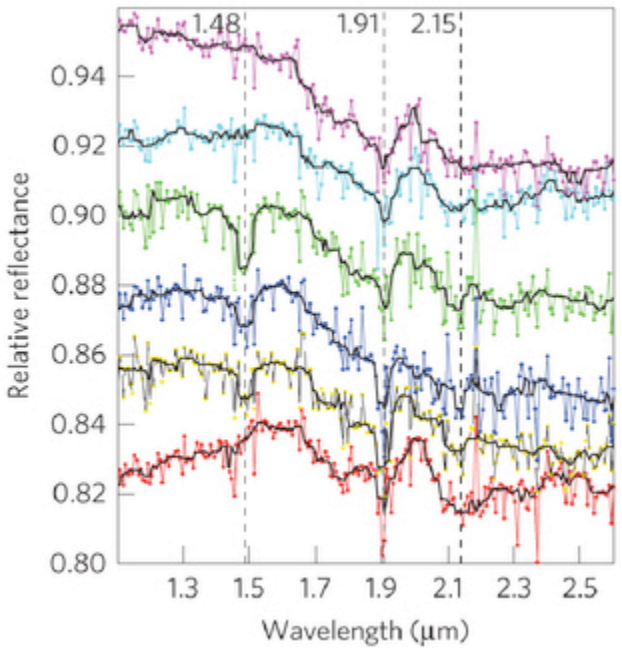
ESP_011428_1380
02 January 2007

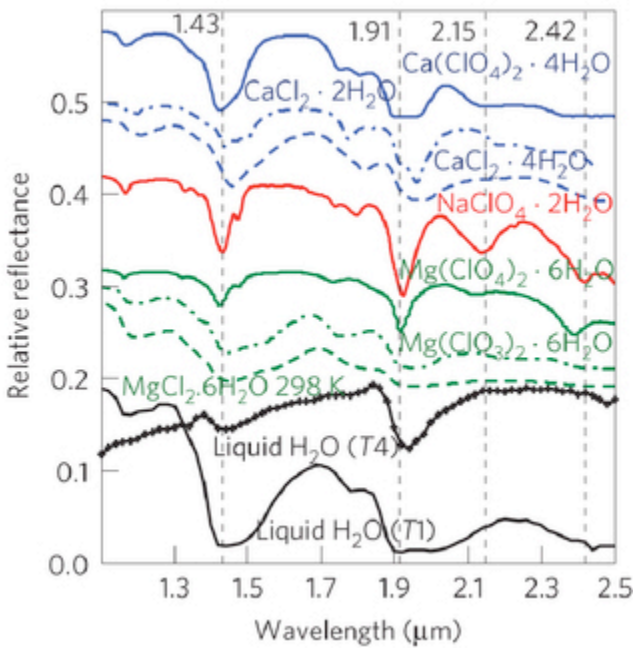
Palikir Crater

Results from Spectroscopy CRISM on-board Mars Reconnaissance Orbiter (MRO)

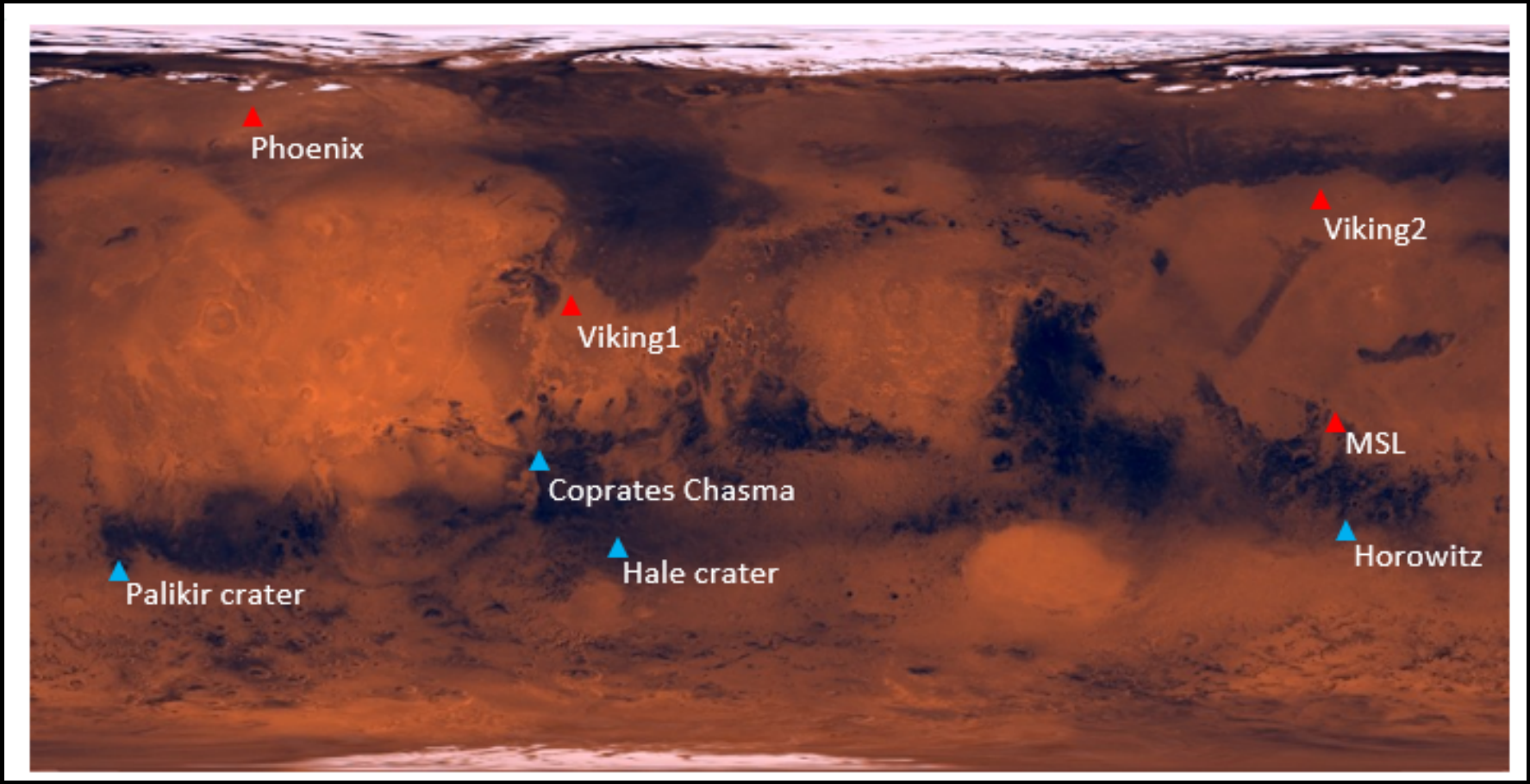


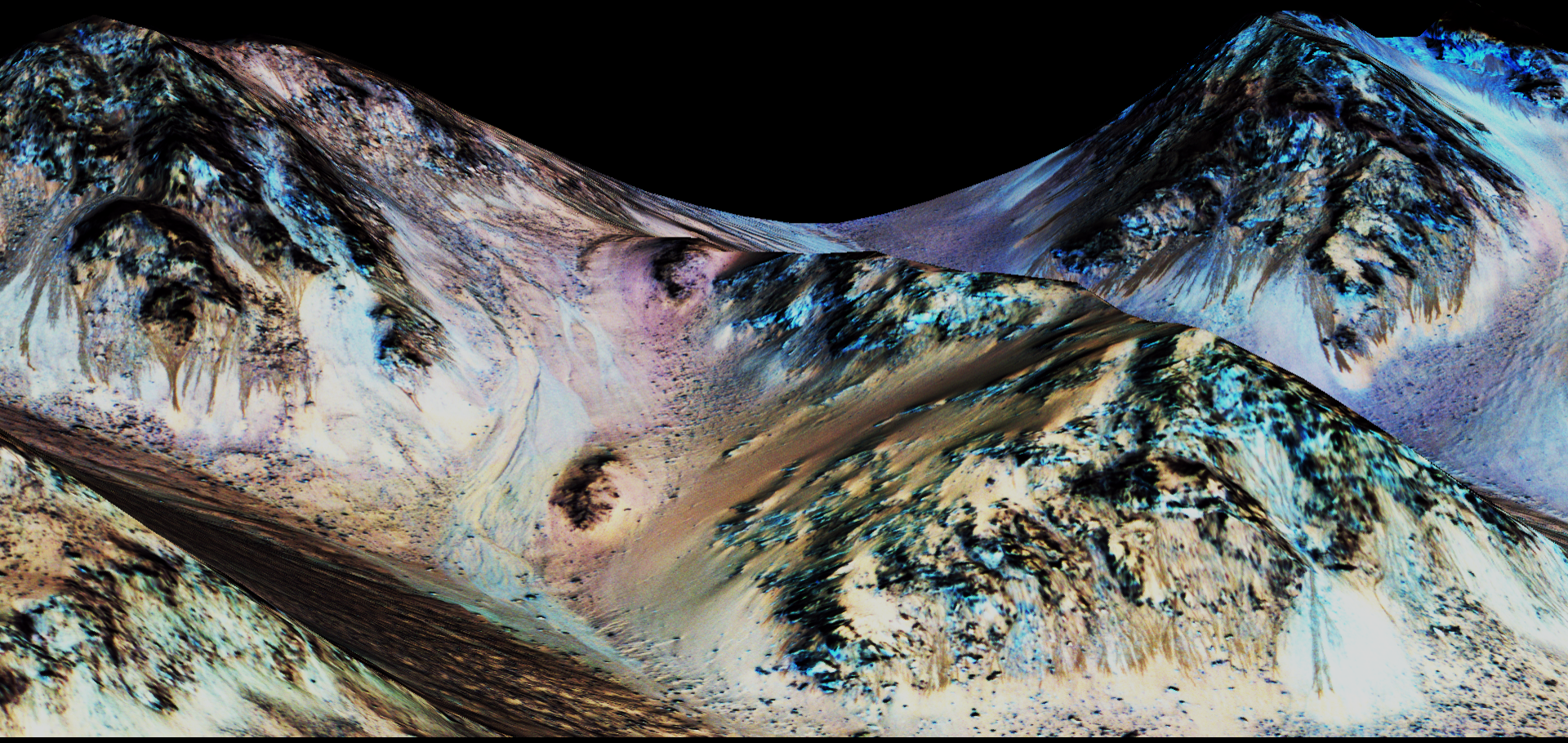






Distribution of Perchlorates on Mars





These results may point to more habitable condition on the near surface of Mars than previously thought.

AAAC Proposal Pressures Study Group – Interim Report Summary

Dr. Priscilla Cushman, Univ. of MN

Summary & Remarks

- Increase in the number of PIs and in many programs long no-growth budget profiles have led to decreasing proposal success rates.
- The cause does not lie in changing demographics, proposal quality, grant size.
- The tendency to recycle proposals exacerbates the problem.
- Lower success rates stress agencies, reviewers, the community, and the nation.
- Success rates greater than 30% are healthy.
- Success rates of 15% are not sustainable – anecdotally people are leaving, panels are more risk averse, and new researchers are not entering the field.

The solutions are not clear.

- More funding
- Rebalancing the program
- Fiddling with the process – grant size, grant opportunities
- Decreasing the size of the U.S. astronomical science community – strategically or not

PROPOSAL SUCCESS RATE	P (no funding) 1 try	P (no funding) 2 tries	P (no funding) 3 tries	P (no funding) 4 tries	P (no funding) 5 tries
10%	90%	81%	73%	66%	59%
15%	85%	72%	61%	52%	44%
20%	80%	64%	51%	41%	33%
25%	75%	56%	42%	32%	24%
30%	70%	49%	34%	24%	17%
35%	65%	42%	27%	18%	12%

Table 1. *Probabilities of unfunded proposals for different hypothetical funding rates and number of proposal attempts. The green shaded cell represents the state of the field circa 2003 (see Fig. 1). The red shaded cell represents the impending situation expected by FY2018 in the absence of portfolio rebalancing. The yellow shaded cell is the nominal "absolute minimum" benchmark identified here as the point at which new researchers spend more time proposing than publishing papers; it is not a sustainable benchmark and should be regarded as a temporary acceptable minimum.*

Big Data Task Force Update

Status:

- Nominees: 8 pending appointment; 2 in nomination process
- Executive Secretary: Dr. Erin Smith, NASA Ames (on detail to HQ)
- Chair-nominee engaged and drafting ideas
- First telecon meeting within next few months
- NAC SC asked the Subcs to discuss BDTF Goals/Purpose at Fall mtgs, feedback received:

Linkages/Dialogues:

- Link with existing efforts (e.g. Planetary Data System workshops, virtual astronomy model)
- Invite data system mgrs, modelers, simulation experts, industry working w/ NASA Ames, archivers)
- Leverage with industry partners, learn methods from univs and govt science centers

Assess/Inform:

- Understand big data first within subfields of discipline, id synergies, needs and gaps
- Cross-pollinate across disciplines/NASA SMD divs/Fed agencies - *big data is happening in all sciences*
- Gather data on big data needs and activities and have a feedback mechanism so the Subcs/disciplines benefit from this effort (e.g. survey to industry members, AAS town hall)

Big Data Aspects to Address:

- Usability of Data, Datasets and Databases; Analysis; Storage; Visualization (e.g. hyperwall); Utilizing State-of-the-Art IT Systems and Tools

SMD Science Education Restructuring Strategy and Selections

- Selections build upon legacy of excellence, balanced across diverse audiences, and fit within annual budget of $42M/year towards meeting NASA Science Mission Directorate's desired Outcome and Objectives
- 27 of 73 compliant proposals selected (37%) for negotiations leading to cooperative agreement awards
- 15 are from "Legacy" institutions (56%)
- 3 selections support the 2017 Total Solar Eclipse, allowing for one full academic year of preparation
- Negotiations will be based on either full selection or partial selections based on peer evaluations or funding limitations
- Awards planned to be completed by the end of calendar year 2015

Map of NASA Science Mission Directorate Science Education Selections